

Chromatography in the Fast Lane

Fast GC

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Application Engineer

December 13, 2018



Questions to Ask

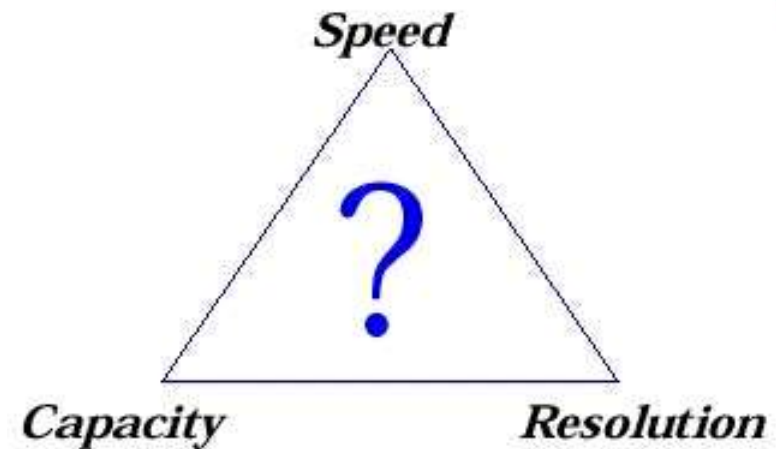
What information do you need from your analysis?

Do you have more baseline than you need between your peaks?

Do you need to resolve all of the components?

Variables for Shortening Run Times

- Stationary Phase
- Temperature Programming
- Carrier Gas: type and linear velocity
- Shorten Column Length
- Decrease Film Thickness
- Decrease Internal Diameter



Resolution

$$R_s = \frac{\sqrt{N}}{4} \left(\frac{k}{k+1} \right) \left(\frac{\alpha-1}{\alpha} \right)$$

Factors effecting R_s

Efficiency

$$N = f(\text{gas}, L, r_c)$$

Retention

$$k = f(T, d_f, r_c)$$

Selectivity

$$\alpha = f(T, \text{phase})$$

Variables

L

Length

r_c

radius

d_f

film thickness

T

Temperature

Resolution

$$R_s = \frac{\sqrt{N}}{4} \left(\frac{k}{k+1} \right) \left(\frac{\alpha-1}{\alpha} \right)$$

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$N = f$ (gas, L, r_c)

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Selectivity

$\alpha = f$ (T, **phase**)

Variables

L

Length

r_c

radius

d_f

film thickness

T

Temperature

Stationary Phase - Common Types

Siloxane polymers

Poly(ethylene) glycols

Porous polymers

Relative spacing of the chromatographic peaks

The result of all non-polar, polarizable and polar interactions that cause a stationary phase to be more or less retentive to one analyte than another

Optimizing Selectivity

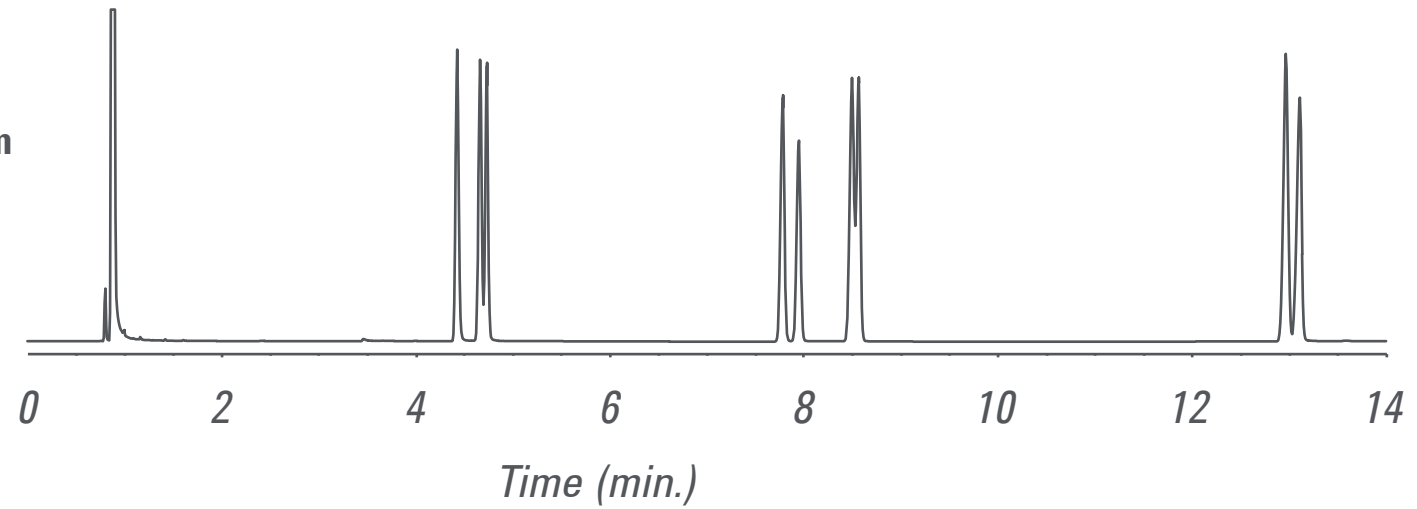
Match analyte polarity to stationary phase polarity

-like dissolves like(oil and water don't mix)

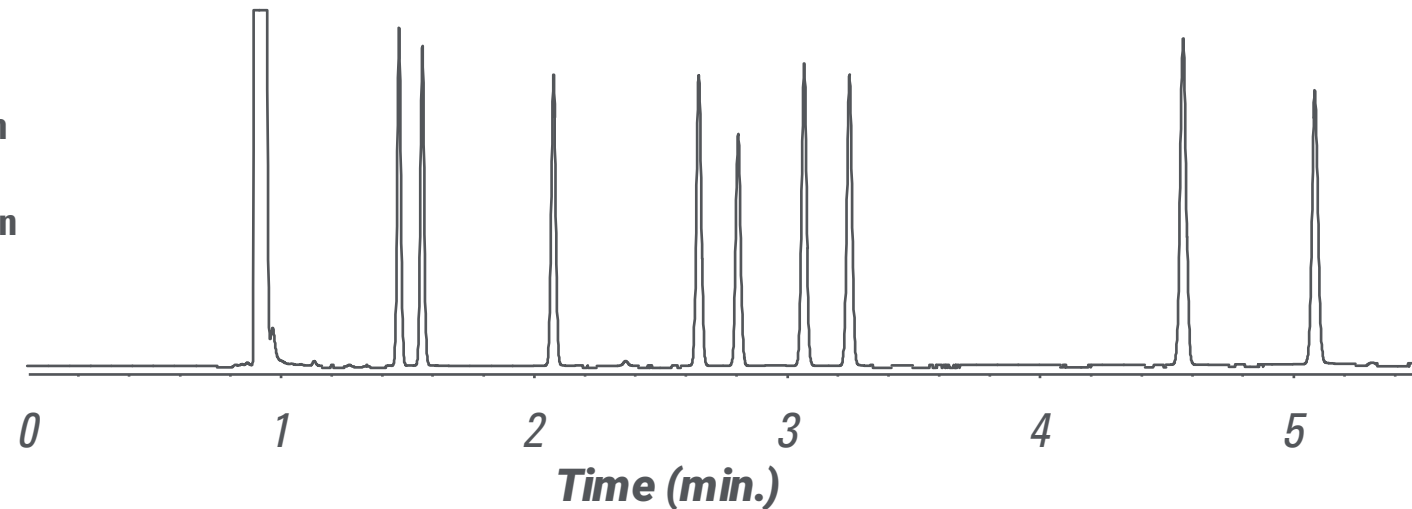
Take advantage of unique interactions between analyte and stationary phase functional groups

Start with the Right Phase

DB-1
15m x 0.32mm, 0.25 μ m
Oven:
40°C for 2 min
40-120°C at 5°C/min



DB-Wax
15m, 0.32mm, 0.25 μ m
Oven:
80-190°C at 20°C/min



Resolution

$$R_s = \frac{\sqrt{N}}{4} \left(\frac{k}{k+1} \right) \left(\frac{\alpha-1}{\alpha} \right)$$

Factors effecting R_s

Efficiency

$$N = f(\text{gas}, L, r_c)$$

Retention

$$k = f(T, d_f, r_c)$$

Selectivity

$$\alpha = f(T, \text{phase})$$

Variables

L

Length

r_c

radius

d_f

film thickness

T

Temperature

Column Length and Efficiency (Theoretical Plates)

Length (m)	n
15	69,450
30	138,900
60	277,800

0.25 mm ID
n/m = 4630 (for k = 5)

Column Length and Resolution

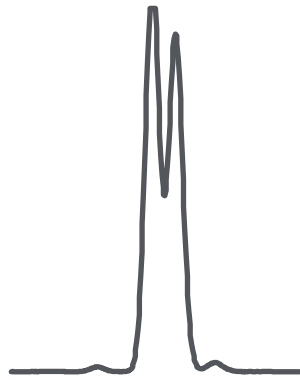
$$R \propto \sqrt{n} \propto \sqrt{L}$$

Length X 4 = Resolution X 2

$$t \propto L$$

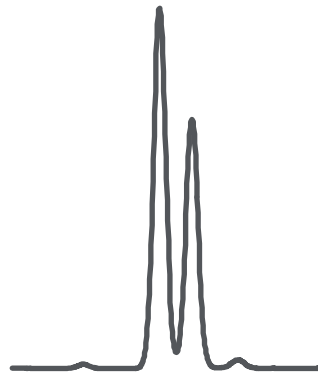
Column Length VS Resolution and Retention: Isothermal

R=0.84
2.29 min



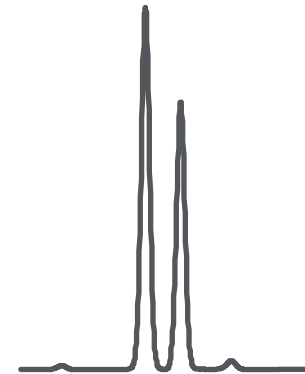
15 m

R=1.16
4.82 min



30 m

R=1.68
8.73 min

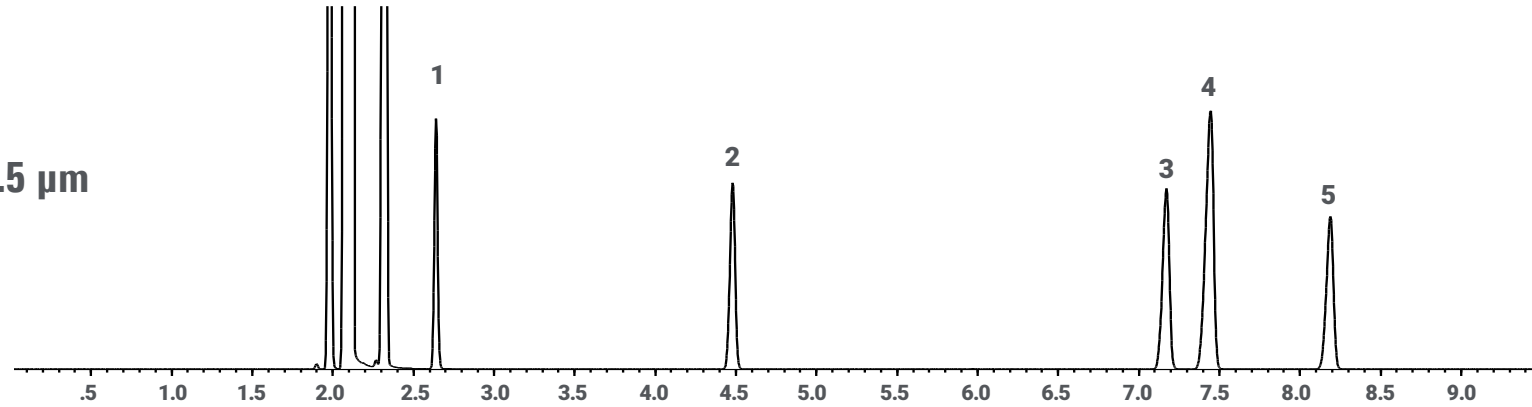


60 m

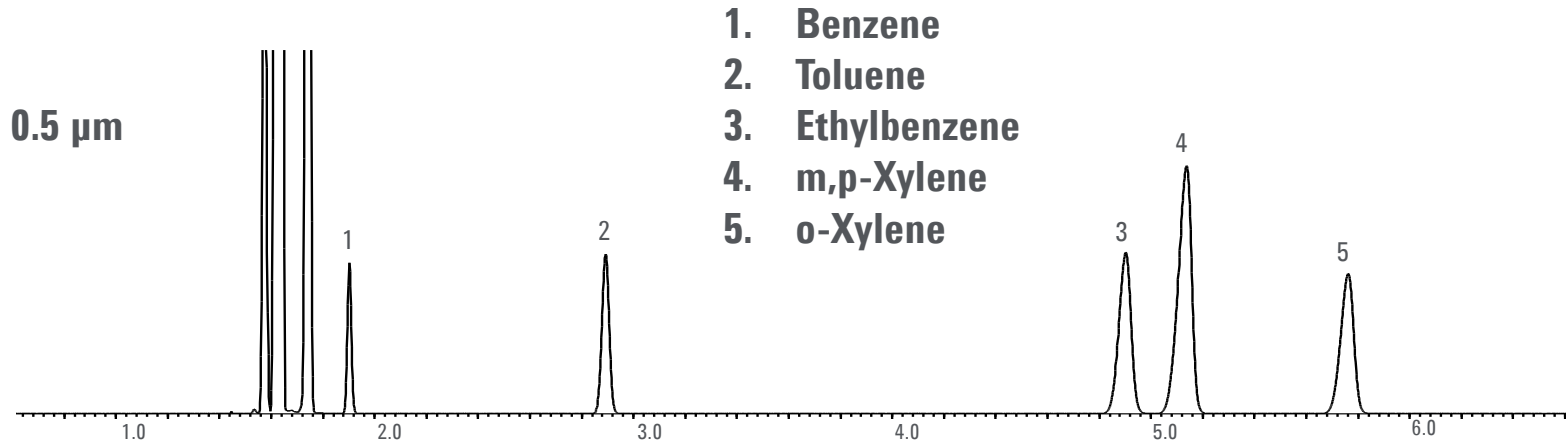
**Double the plates, double the time
but not double the the resolution**

DECREASE THE LENGTH

DB-5
30 m
0.53 mm I.D., 0.5 μ m

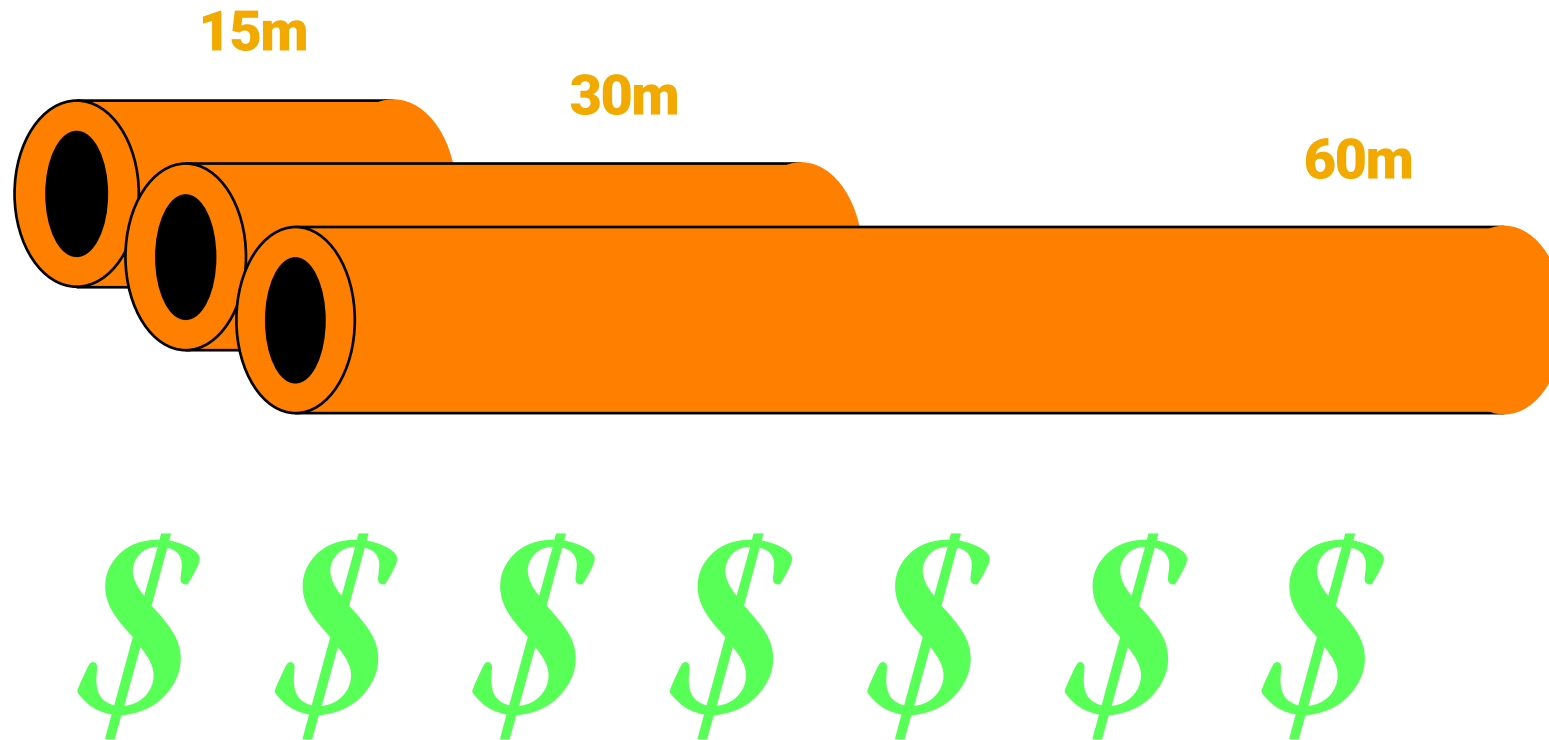


DB-5
15 m
0.53 mm I.D., 0.5 μ m



BTEX
Carrier: Helium, 36 cm/sec at 40°C
Oven : 40°C for 3 min, 5°/min to 100°C

Column Length and Cost



Length Summary

If you Decrease Length:

Efficiency

Decrease

Resolution

Decrease

Analysis Time

Decrease

Pressure

Decrease

Cost

Decrease

Resolution

$$R_s = \frac{\sqrt{N}}{4} \left(\frac{k}{k+1} \right) \left(\frac{\alpha-1}{\alpha} \right)$$

Factors effecting R_s

Efficiency

$$N = f(\text{gas, } L, r_c)$$

Retention

$$k = f(T, d_f, r_c)$$

Selectivity

$$\alpha = f(T, \text{phase})$$

Variables

L

Length

r_c

radius




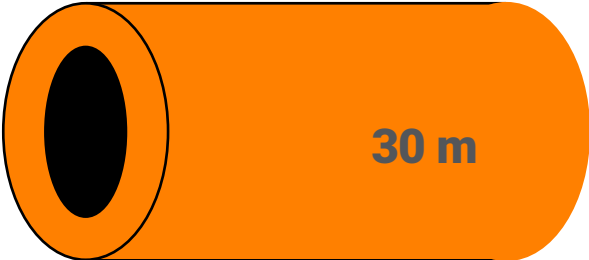
d_f

film thickness

T

Temperature

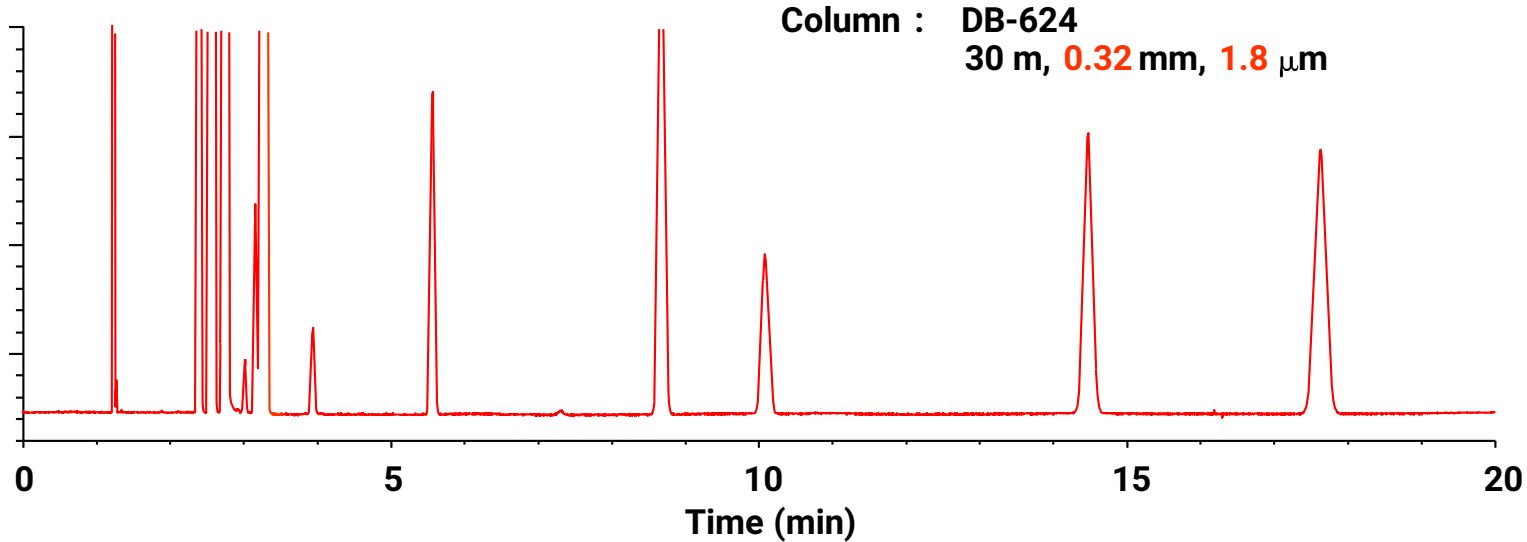
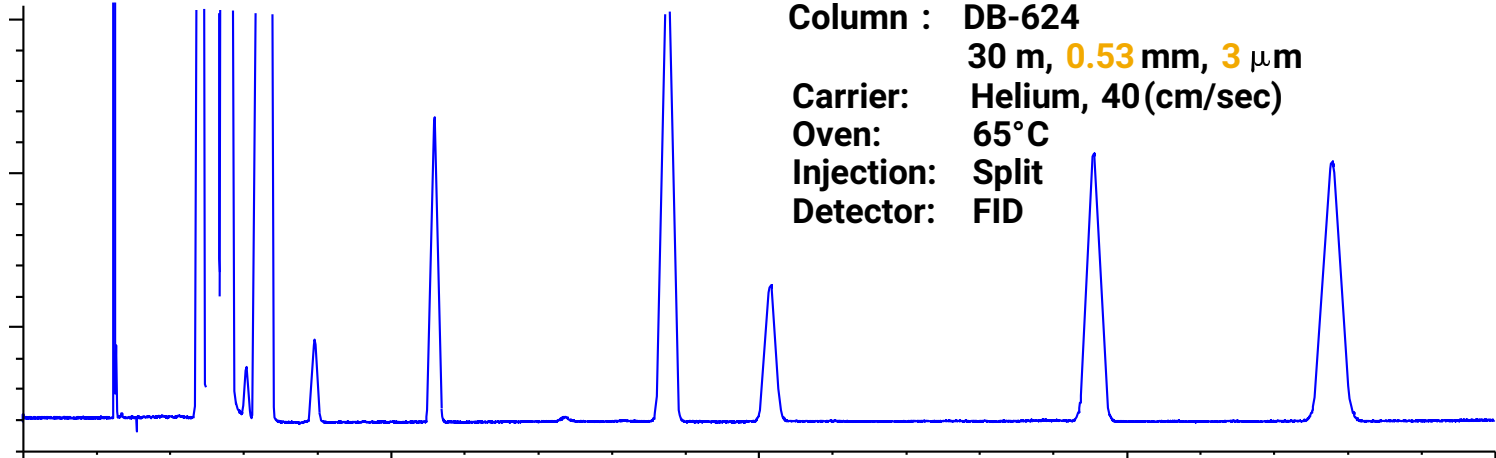
Column Diameter - Theoretical Efficiency

	Total Plates	I.D. (mm)	n/m
 5 m	N ~ 112,000	0.05	23,160
 10 m	N ~ 112,000	0.10	11,580
<hr style="border-top: 1px dashed #e91e63;"/>			
 20 m	N ~ 112,000	0.18	6,660
 30 m	N ~ 112,000	0.20	5830
		0.25	4630
		0.32	3660
		0.45	2840
		0.53	2060

k = 5

Different Column I. D.

Equal Phase Ratios



PHASE RATIO (β)

Film Thickness

Column Dimensions

30 m x .53 mm x 3.0 μm

30 m x .32 mm x 1.8 μm

Phase Ratio β

44

44

$$K_C = k \beta$$

$$\beta = \frac{r}{2d_f}$$

Column Diameter and Capacity

	I.D. (mm)	Capacity (ng)
	0.05	1-2
	0.10	6-13
	0.18	25-55
	0.20	35-70
Like Polarity Phase/Solute 0.25 μm film thickness	0.25	80-160
	0.32	110-220
	0.45	600-800
	0.53	1000-2000

Column Diameter - Inlet Head Pressures (Helium)

I.D (mm)	Pressure (psig)
0.05	275-400
0.10	90-130
0.18	30-45
0.20	25-40
0.25	15-25
0.32	10-20
0.45	3-7
0.53	2-4

**30 meters
Hydrogen pressures x 1/2**

Column Diameter and Carrier Gas Flow

Lower flow rates: Smaller diameter columns

Higher flow rates: Larger diameter columns

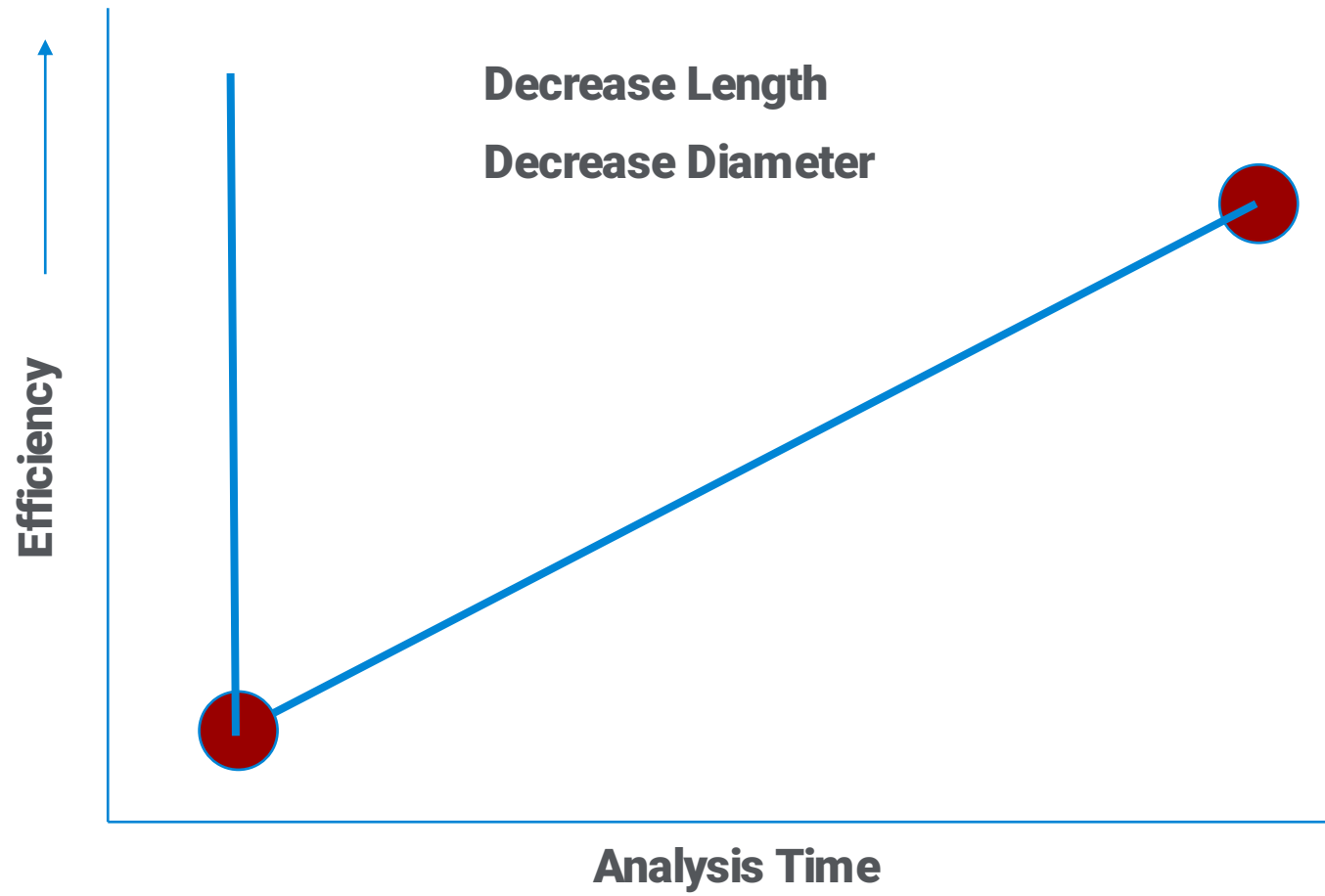
Low flow rates : GC/MS
High flow rates: Headspace, purge & trap

Diameter Summary

If you decrease the inside diameter:

Efficiency	Increase
Resolution	Increase
Pressure	Increase
Capacity	Decrease
Flow rate	Decrease

Combining a change in Length with a change in Diameter



Carrier Gas Considerations

Best velocity?

Optimal range of velocities

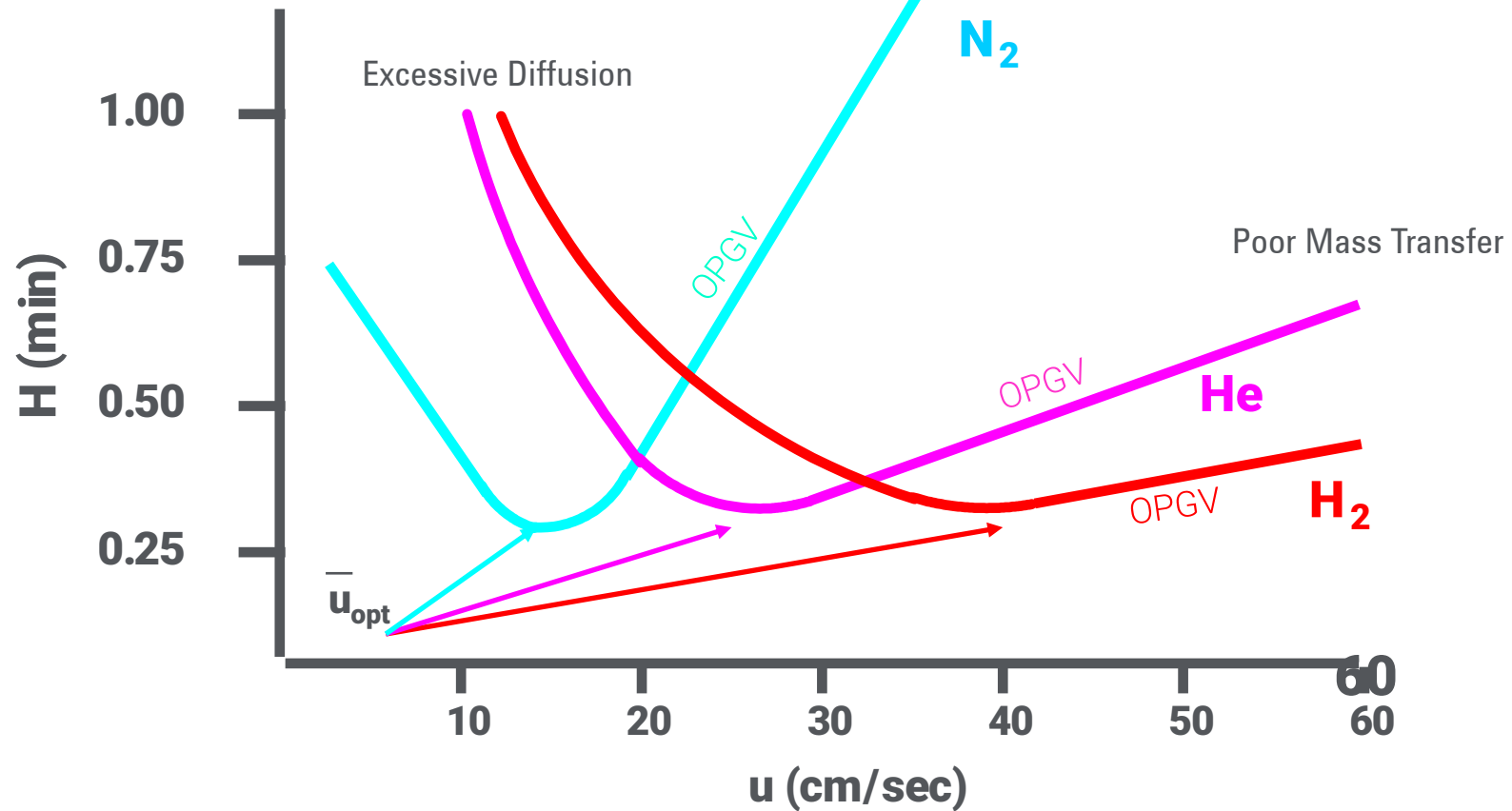
Too low or high results in loss of resolution

Balance resolution and analysis time

BUT... there is no LAW against going FASTER

Carrier Gas Considerations

Van Deemter Curve



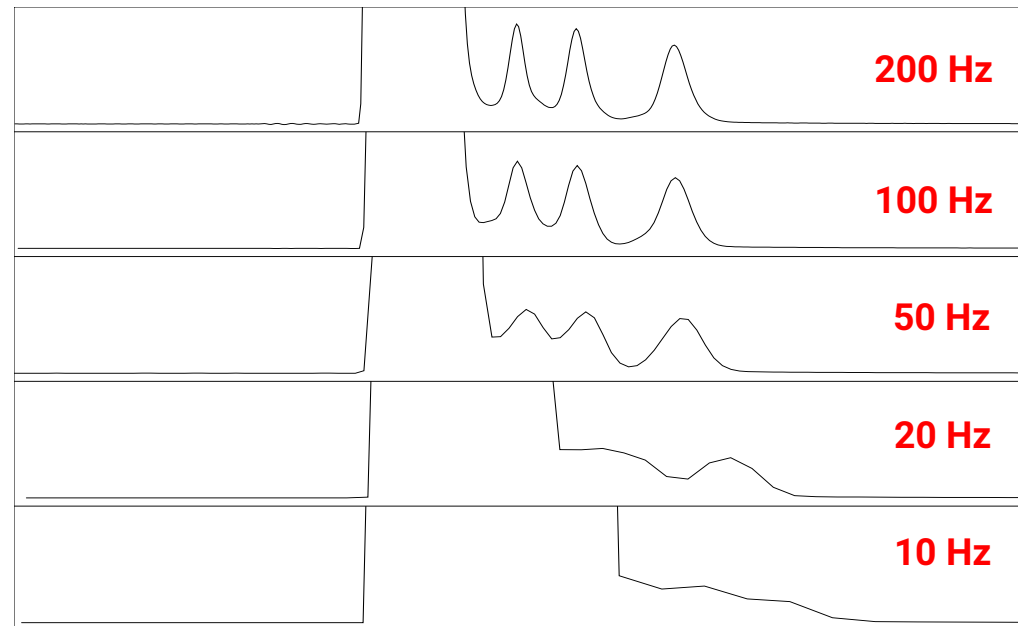
Carrier Gas Considerations

Utilizing Computer Controlled Flow Ramping (EPC)

Lonely Late Eluters? = P 

Decrease retention and overall run time by **increasing pressure**
(speed up the gas!)

Fast Detector Electronics – 6890 FID



Proper peak quantitation typically requires a minimum of 10 data points per peak

10 Hz data rate: (peaks less than one second wide will have less than 10 data points)

200 Hz data rate: (peaks as narrow as 50 msec can be handled reliably)

Easy Options with Method Translation Software

Different Column Dimensions

Switch He to H₂ Carrier Gas and Try Faster Velocities

Same Column & Gas Type but Faster Velocities

Combination of all of the above

Temperature Programming

30m, 0.25mm ID

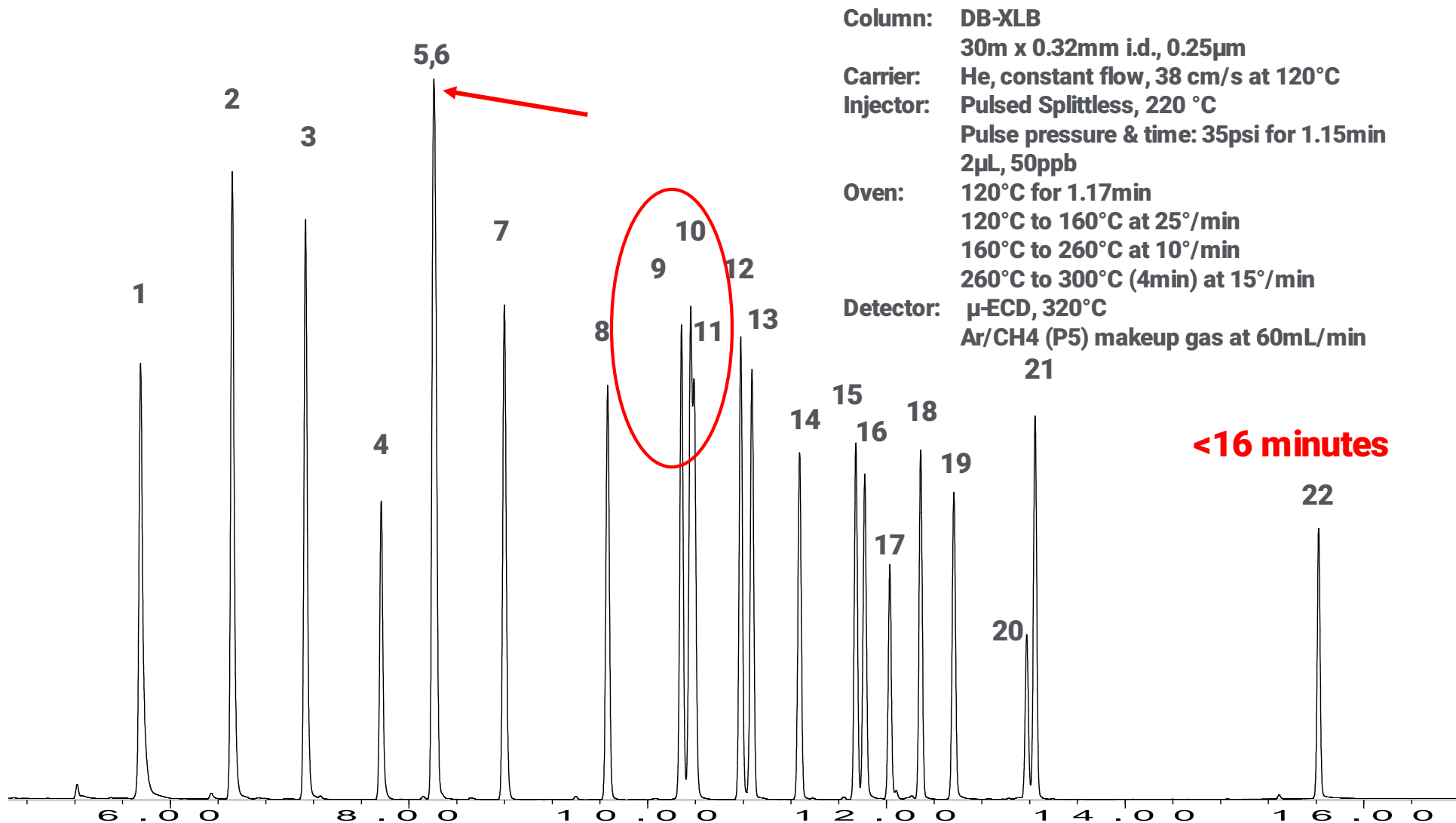


10m, 0.1mm ID



Temperature program must be modified to give same temperature of elution (i.e. faster ramps, shorter hold times)

CLP-Pesticides - Original "Improved" Method 0.32mm I.D., Helium Carrier Gas



Column: DB-XLB
30m x 0.32mm i.d., 0.25µm
Carrier: He, constant flow, 38 cm/s at 120°C
Injector: Pulsed Splittless, 220 °C
Pulse pressure & time: 35psi for 1.15min
2µL, 50ppb
Oven: 120°C for 1.17min
120°C to 160°C at 25°/min
160°C to 260°C at 10°/min
260°C to 300°C (4min) at 15°/min
Detector: µ-ECD, 320°C
Ar/CH4 (P5) makeup gas at 60mL/min

<16 minutes

Input Original Method Parameters

GC Method Translation - EPACLP.MXD

Criterion: Translate Only Best Efficiency Fast Analysis None **Speed gain: 1.17407**

Original Method

Translated Method

Column

Length, m

Internal Diameter, μm

Film

Thickness, μm

Phase Ratio

Carrier Gas

Enter one Setpoint

Head Pressure, psi

Flow Rate, mLn/min

Outlet Velocity, cm/sec

Average Velocity, cm/sec

Hold-up Time, min

Outlet Pressure (absolute), psi

Ambient Pressure (absolute), psi

Oven Temperature 3-ramp Program

	Ramp Rate	Final Temp.	Final Time
	$^{\circ}\text{C}/\text{min}$	$^{\circ}\text{C}$	min
Initial		120	1.17
Ramp 1	25	160	0
Ramp 2	10	260	0
Ramp 3	15	300	4

Sample Information None

Detailed description: The image shows a software interface for translating GC methods. It is divided into three main vertical sections: 'Original Method', 'Translated Method', and a central control area. The 'Original Method' section contains input fields for column parameters (Length: 30 m, ID: 320 μm , Thickness: 0.25 μm , Phase Ratio: 320.0), carrier gas (Helium), head pressure (12.786 psi), flow rate (2.0502 mLn/min), outlet velocity (56.20 cm/sec), average velocity (38 cm/sec), and hold-up time (1.31579 min). The 'Translated Method' section shows the resulting parameters, with some values in blue (e.g., 320 μm , 2.5600 mLn/min, 44.61 cm/sec, 1.12070 min). The central control area includes a 'Carrier Gas' dropdown (Helium), a 'Head Pressure' dropdown (psi), a 'Flow Rate' dropdown (mLn/min), and an 'Oven Temperature' section with a '3-ramp Program' dropdown and a table of ramp parameters. Red arrows point from the 'Original Method' section to the 'Translated Method' section, and a red circle highlights the 'Enter one Setpoint' checkbox. A yellow box highlights the 'Original Method' section.

Same Column and Gas Type Fast Analysis (OPGV)

GC Method Translation - EPACLP.MXD

Criterion: Translate Only Best Efficiency Fast Analysis None Speed gain: 1.17407

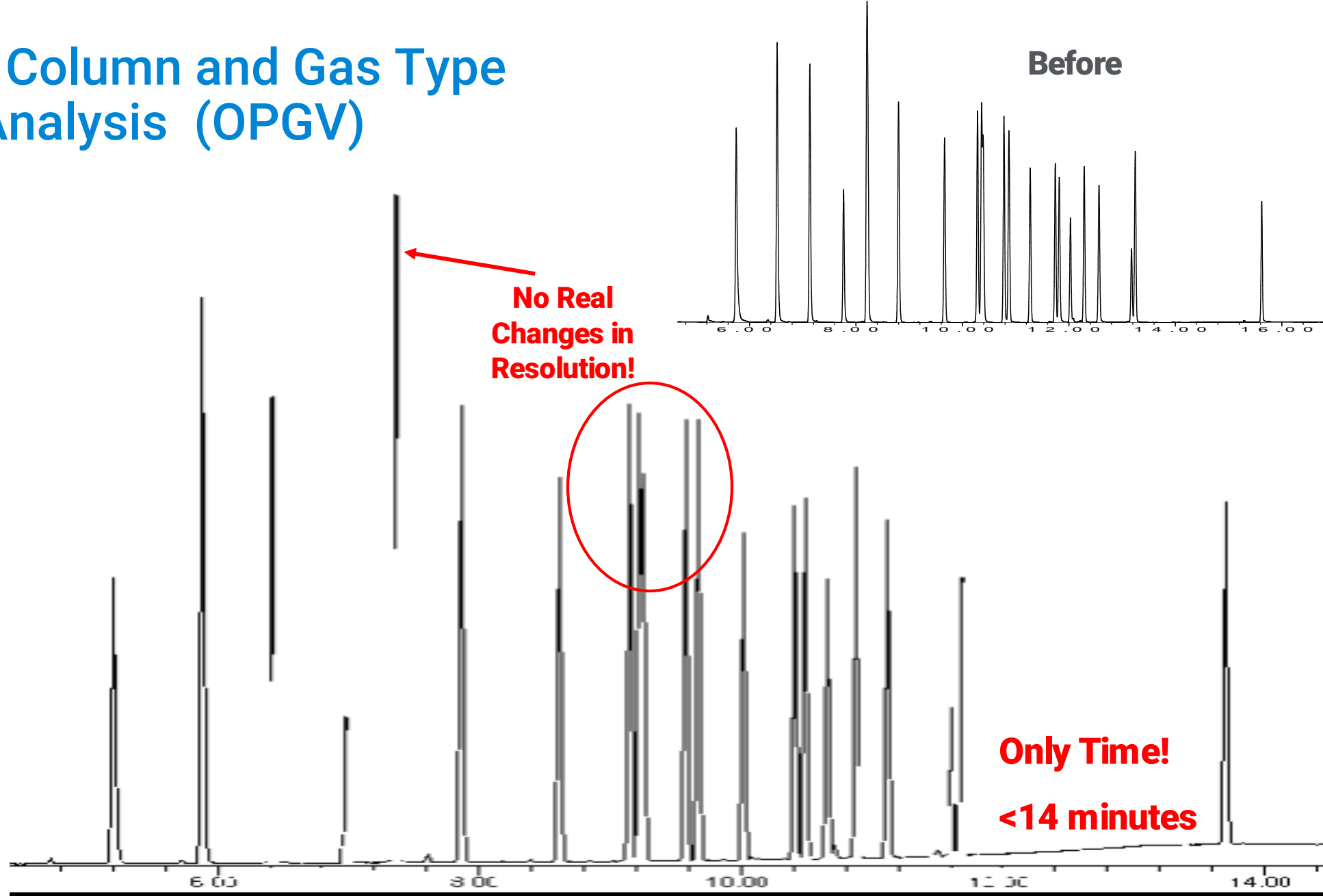
	Original Method	Translated Method																																										
Column																																												
Length, m	30	<input checked="" type="checkbox"/> 30																																										
Internal Diameter, μm	320	<input checked="" type="checkbox"/> 320																																										
Film																																												
Thickness, μm	0.25	<input type="radio"/> Unlock																																										
Phase Ratio	320.0	<input checked="" type="radio"/> 0.25																																										
		<input type="radio"/> 320.0																																										
Carrier Gas	Helium	<input type="checkbox"/> Helium																																										
Enter one Setpoint																																												
Head Pressure, psi	12.786	15.126																																										
Flow Rate, mL/min	2.0502	2.5600																																										
Outlet Velocity, cm/sec	56.20	70.17																																										
Average Velocity, cm/sec	38	44.61																																										
Hold-up Time, min	1.31579	1.12070																																										
Outlet Pressure (absolute), psi	14.696	<input type="checkbox"/> 14.696																																										
Ambient Pressure (absolute), psi	14.696	<input type="checkbox"/> 14.696																																										
Oven Temperature 3-ramp Program																																												
	<table border="1"> <thead> <tr> <th>Ramp Rate</th> <th>Final Temp.</th> <th>Final Time</th> </tr> <tr> <th>$^{\circ}\text{C}/\text{min}$</th> <th>$^{\circ}\text{C}$</th> <th>min</th> </tr> </thead> <tbody> <tr> <td></td> <td>120</td> <td>1.17</td> </tr> <tr> <td>Ramp 1</td> <td>25</td> <td>160</td> </tr> <tr> <td>Ramp 2</td> <td>10</td> <td>260</td> </tr> <tr> <td>Ramp 3</td> <td>15</td> <td>300</td> </tr> <tr> <td></td> <td></td> <td>4</td> </tr> </tbody> </table>	Ramp Rate	Final Temp.	Final Time	$^{\circ}\text{C}/\text{min}$	$^{\circ}\text{C}$	min		120	1.17	Ramp 1	25	160	Ramp 2	10	260	Ramp 3	15	300			4	<table border="1"> <thead> <tr> <th>Ramp Rate</th> <th>Final Temp.</th> <th>Final Time</th> </tr> <tr> <th>$^{\circ}\text{C}/\text{min}$</th> <th>$^{\circ}\text{C}$</th> <th>min</th> </tr> </thead> <tbody> <tr> <td></td> <td>120</td> <td>0.997</td> </tr> <tr> <td></td> <td>29.352</td> <td>160</td> </tr> <tr> <td></td> <td>11.741</td> <td>260</td> </tr> <tr> <td></td> <td>17.611</td> <td>300</td> </tr> <tr> <td></td> <td></td> <td>3.407</td> </tr> </tbody> </table>	Ramp Rate	Final Temp.	Final Time	$^{\circ}\text{C}/\text{min}$	$^{\circ}\text{C}$	min		120	0.997		29.352	160		11.741	260		17.611	300			3.407
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Sample Information None																																												

Transfer same dimensions

New Velocity

New Temp. Program

Same Column and Gas Type Fast Analysis (OPGV)



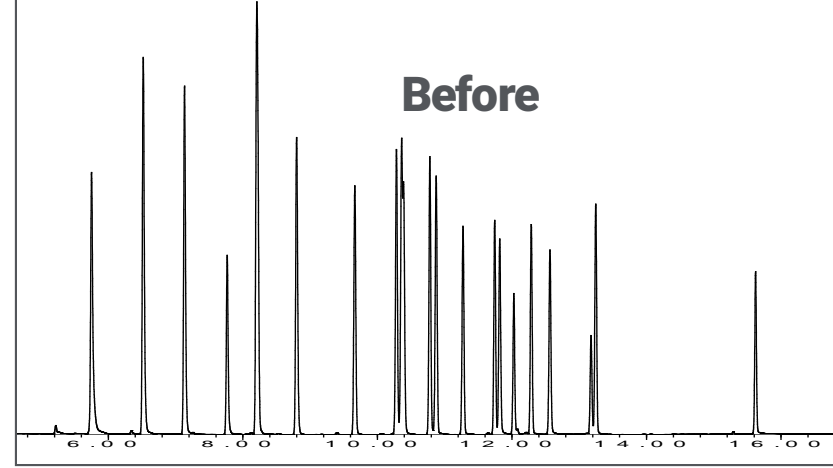
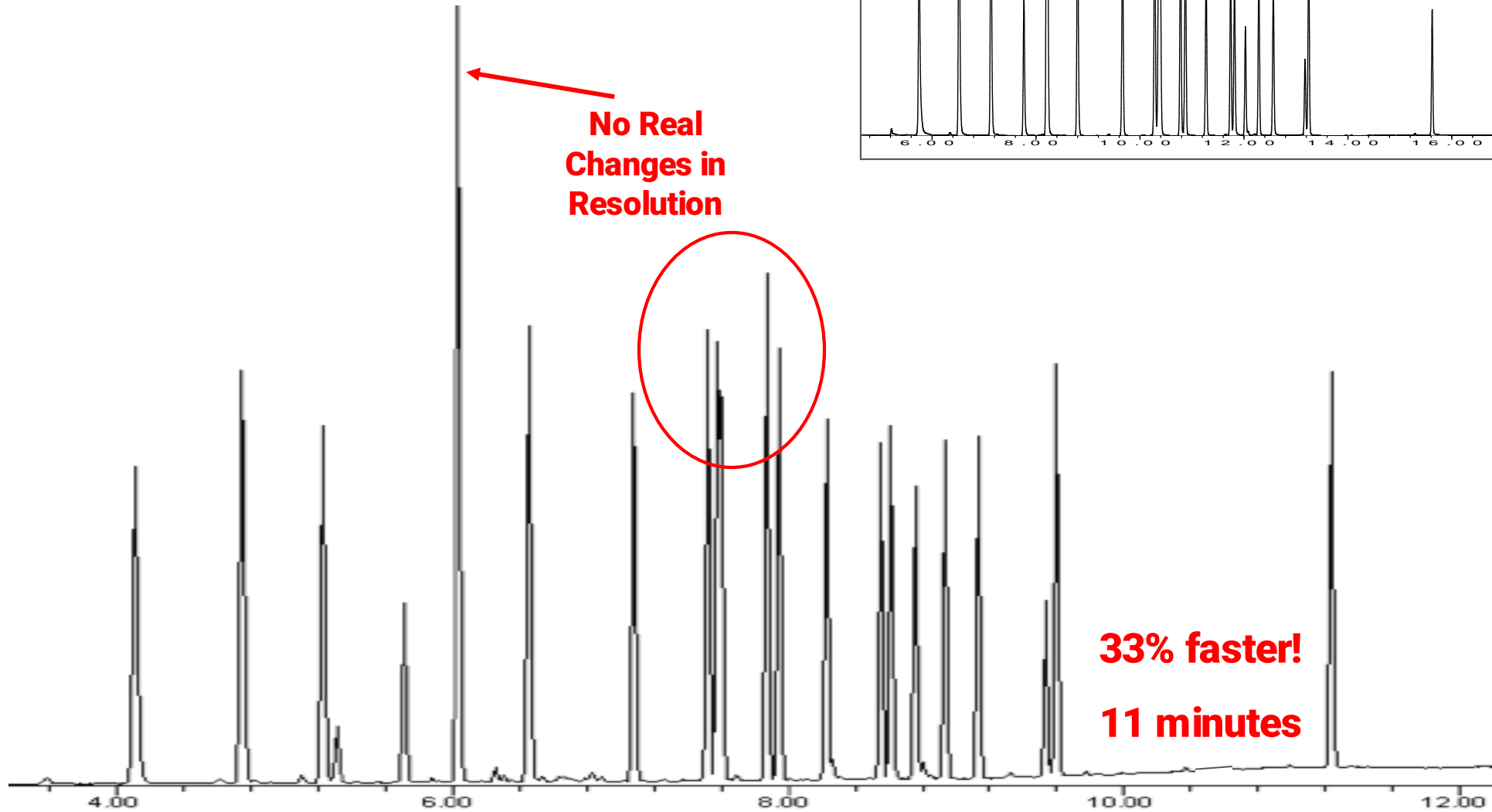
Same Column, Hydrogen Carrier Gas Translate Only

GC Method Translation - EPACLP.MXD

Criterion: Translate Only Best Efficiency Fast Analysis None Speed gain: 1.42668

	Original Method	Translated Method																																										
Column																																												
Length, m	30	<input checked="" type="checkbox"/> 30																																										
Internal Diameter, μm	320	<input checked="" type="checkbox"/> 320																																										
Film		<input type="radio"/> Unlock																																										
Thickness, μm	0.25	<input checked="" type="radio"/> 0.25																																										
Phase Ratio	320.0	<input type="radio"/> 320.0																																										
Carrier Gas	Helium	<input type="checkbox"/> Hydrogen																																										
Enter one Setpoint																																												
Head Pressure, psi	12.786	8.110																																										
Flow Rate, mLn/min	2.0502	2.5628																																										
Outlet Velocity, cm/sec	56.20	70.25																																										
Average Velocity, cm/sec	38	54.21																																										
Hold-up Time, min	1.31579	0.922272																																										
Outlet Pressure (absolute), psi	14.696	<input type="checkbox"/> 14.696																																										
Ambient Pressure (absolute), psi	14.696	<input type="checkbox"/> 14.696																																										
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Sample Information	None																																											

Same Column, H₂ Carrier Gas Translate Only



New Column Dimensions, H₂ Gas, Translate Only

GC Method Translation

Criterion: Translate Only Best Efficiency Fast Analysis None Speed gain: 2.05607

	Original Method	Translated Method																																				
Column																																						
Length, m	30	<input type="checkbox"/> 20																																				
Internal Diameter, μm	316	<input type="checkbox"/> 177																																				
Film		<input checked="" type="radio"/> Unlock																																				
Thickness, μm	0.25	<input type="radio"/> 0.18																																				
Phase Ratio	316.0	<input type="radio"/> 245.8																																				
Carrier Gas	Helium	<input type="checkbox"/> Hydrogen																																				
Enter one Setpoint																																						
Head Pressure, psi	13.126	22.883																																				
Flow Rate, mLn/min	2.0176	1.4126																																				
Outlet Velocity, cm/sec	56.72	126.69																																				
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	120.00	0.569																																				
	160	0.000																																				
	260	0.000																																				
	300	1.945																																				
Sample Information None																																						

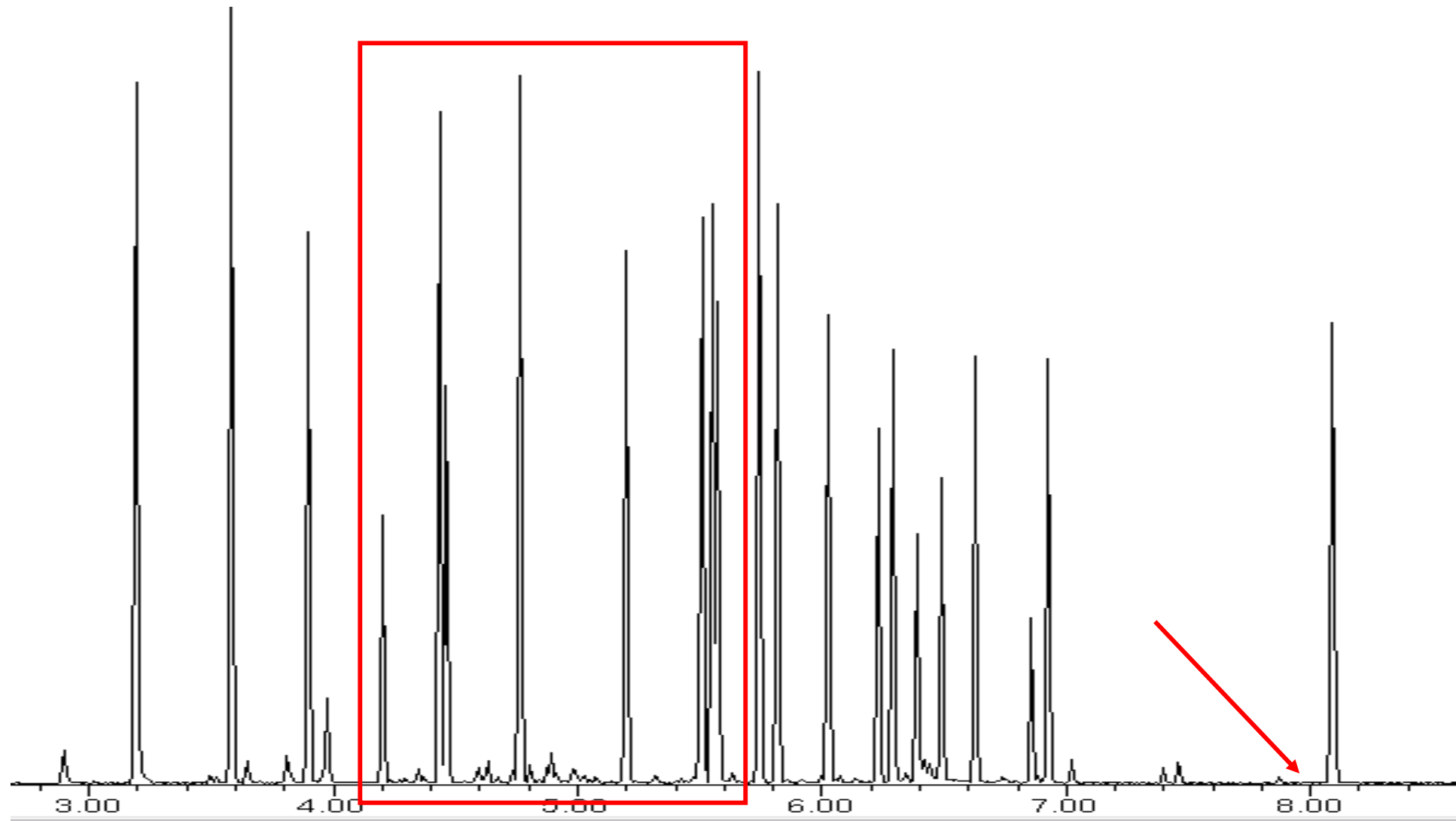
Input NEW dimensions

Close enough (got lucky)

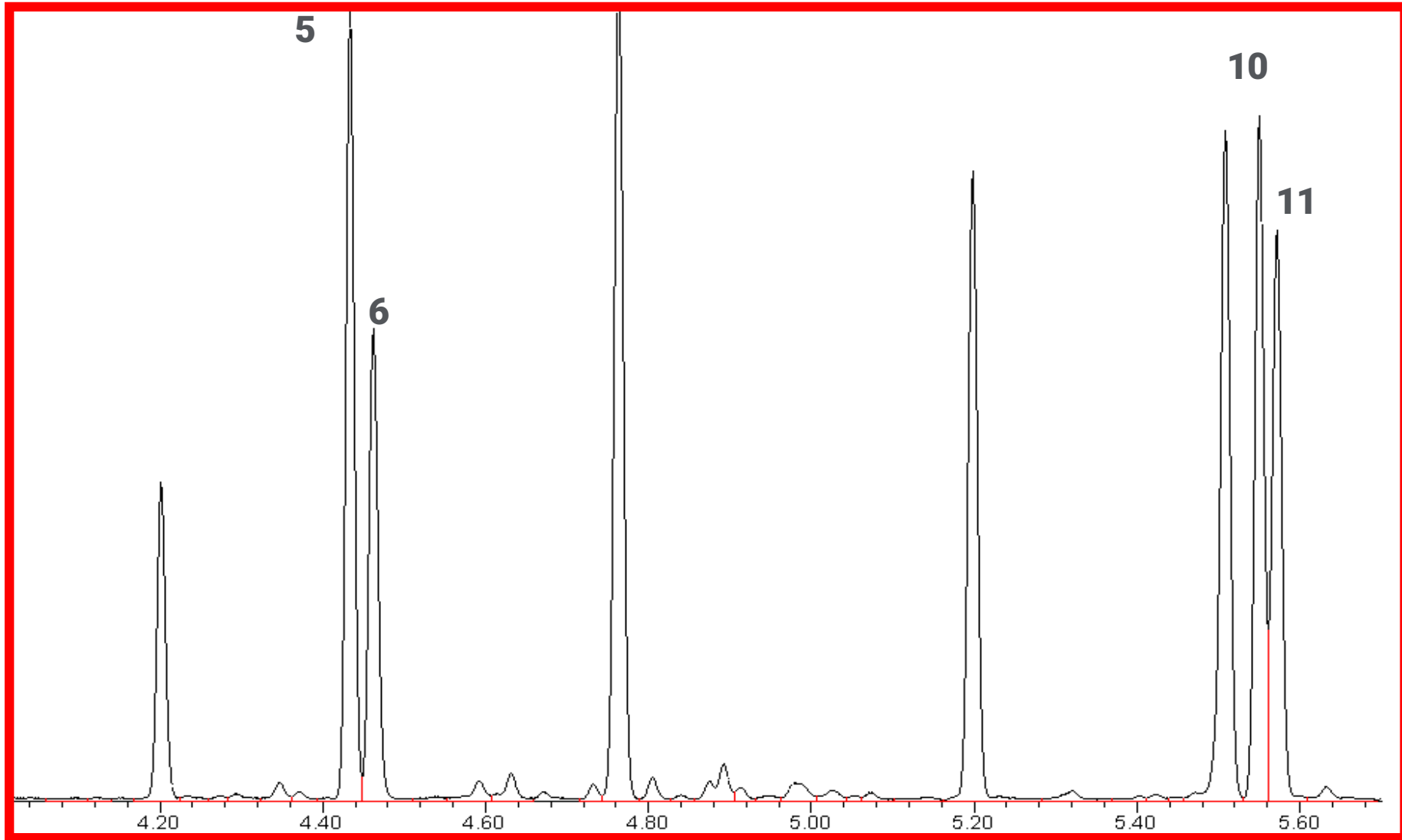
New Velocity

New Temp. Program

New Column Dimensions, H2 Gas, Translate Only



New Column Dimensions, H2 Gas, Translate Only



New Column Dimensions, H2 Gas, Fast Analysis

GC Method Translation - EPACL.P.MXD

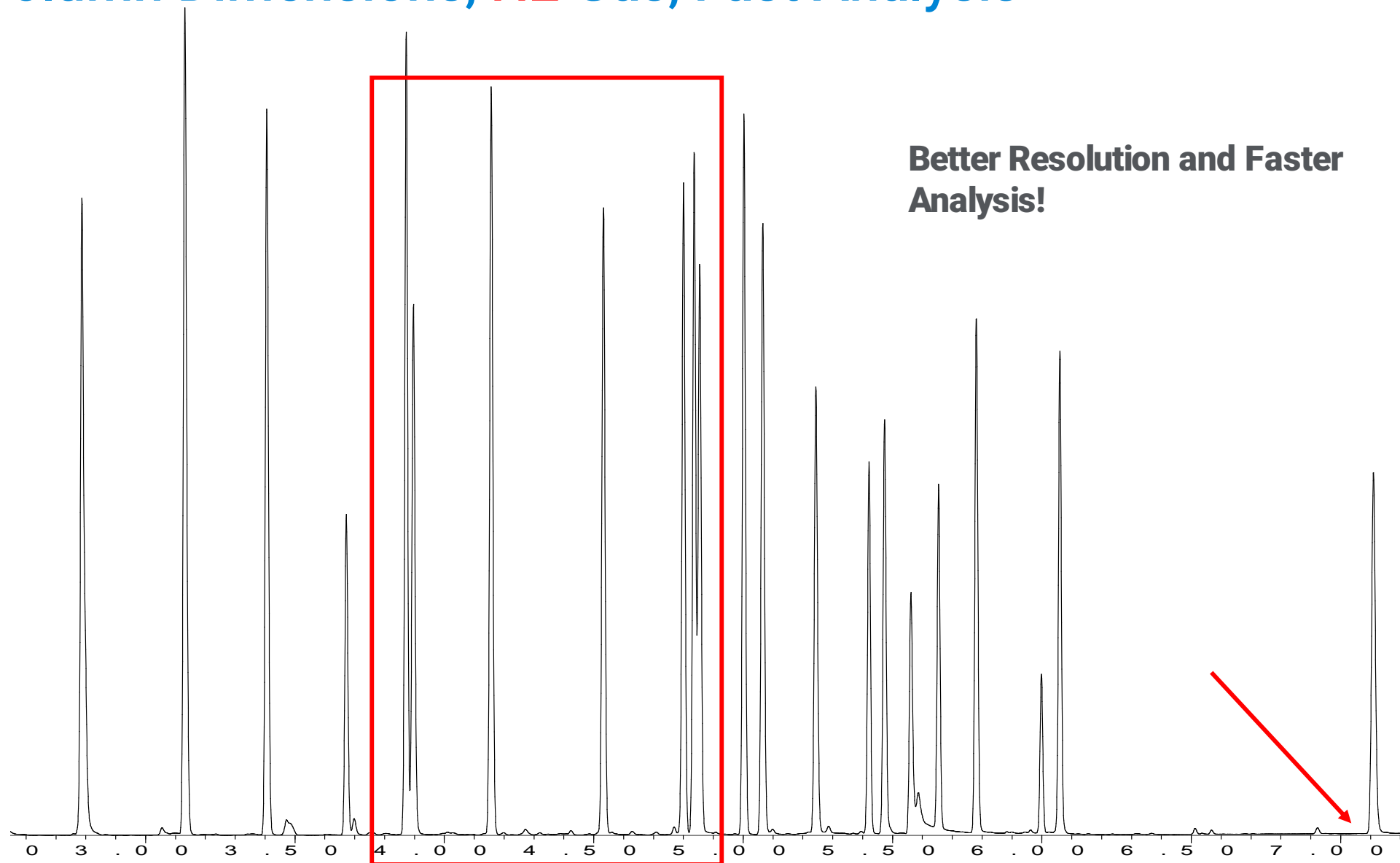
Criterion: Translate Only Best Efficiency Fast Analysis None **Speed gain: 2.34453**

	Original Method	Translated Method																																										
Column																																												
Length, m	30	<input type="checkbox"/> 20																																										
Internal Diameter, μm	320	<input type="checkbox"/> 177																																										
Film		<input checked="" type="radio"/> Unlock																																										
Thickness, μm	0.25	<input type="radio"/> 0.18																																										
Phase Ratio	320.0	<input type="radio"/> 245.8																																										
Carrier Gas	Helium	<input type="checkbox"/> Hydrogen																																										
Enter one Setpoint																																												
Head Pressure, psi	12.786	26.714																																										
Flow Rate, mLn/min	2.0502	1.7700																																										
Outlet Velocity, cm/sec	56.20	158.74																																										
Average Velocity, cm/sec	38	77.31																																										
Hold-up Time, min	1.31579	0.431144																																										
Outlet Pressure (absolute), psi	14.696	<input type="checkbox"/> 14.696																																										
Ambient Pressure (absolute), psi	14.696	<input type="checkbox"/> 14.696																																										
Oven Temperature 3-ramp Program																																												
	<table border="1"> <thead> <tr> <th>Ramp Rate</th> <th>Final Temp.</th> <th>Final Time</th> </tr> <tr> <th>$^{\circ}\text{C}/\text{min}$</th> <th>$^{\circ}\text{C}$</th> <th>min</th> </tr> </thead> <tbody> <tr> <td>Initial</td> <td>120</td> <td>1.17</td> </tr> <tr> <td>Ramp 1</td> <td>25</td> <td>160</td> <td>0</td> </tr> <tr> <td>Ramp 2</td> <td>10</td> <td>260</td> <td>0</td> </tr> <tr> <td>Ramp 3</td> <td>15</td> <td>300</td> <td>4</td> </tr> </tbody> </table>	Ramp Rate	Final Temp.	Final Time	$^{\circ}\text{C}/\text{min}$	$^{\circ}\text{C}$	min	Initial	120	1.17	Ramp 1	25	160	0	Ramp 2	10	260	0	Ramp 3	15	300	4	<table border="1"> <thead> <tr> <th>Ramp Rate</th> <th>Final Temp.</th> <th>Final Time</th> </tr> <tr> <th>$^{\circ}\text{C}/\text{min}$</th> <th>$^{\circ}\text{C}$</th> <th>min</th> </tr> </thead> <tbody> <tr> <td>Initial</td> <td>120</td> <td>0.499</td> </tr> <tr> <td>Ramp 1</td> <td>58.613</td> <td>160</td> <td>0.000</td> </tr> <tr> <td>Ramp 2</td> <td>23.445</td> <td>260</td> <td>0.000</td> </tr> <tr> <td>Ramp 3</td> <td>35.168</td> <td>300</td> <td>1.706</td> </tr> </tbody> </table>	Ramp Rate	Final Temp.	Final Time	$^{\circ}\text{C}/\text{min}$	$^{\circ}\text{C}$	min	Initial	120	0.499	Ramp 1	58.613	160	0.000	Ramp 2	23.445	260	0.000	Ramp 3	35.168	300	1.706
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Sample Information None																																												

New Velocity

New Temp. Program

New Column Dimensions, H₂ Gas, Fast Analysis



New Column Dimensions, H2 Gas, Higher Velocities

GC Method Translation - EPACL.P.MXD

Criterion: Translate Only Best Efficiency Fast Analysis None **Speed gain: 2.57761**

Original Method vs. Translated Method Comparison:

Parameter	Original Method	Translated Method
Column Length, m	30	20
Column Internal Diameter, µm	320	177
Film Thickness, µm	0.25	0.18
Film Phase Ratio	320.0	245.8
Carrier Gas	Helium	Hydrogen
Head Pressure, psi	12.786	29.598
Flow Rate, mLn/min	2.0502	2.0619
Outlet Velocity, cm/sec	56.20	184.91
Average Velocity, cm/sec	38	85
Hold-up Time, min	1.31579	0.392157
Outlet Pressure (absolute), psi	14.696	14.696
Ambient Pressure (absolute), psi	14.696	14.696
Oven Temperature Program	3-ramp Program	3-ramp Program

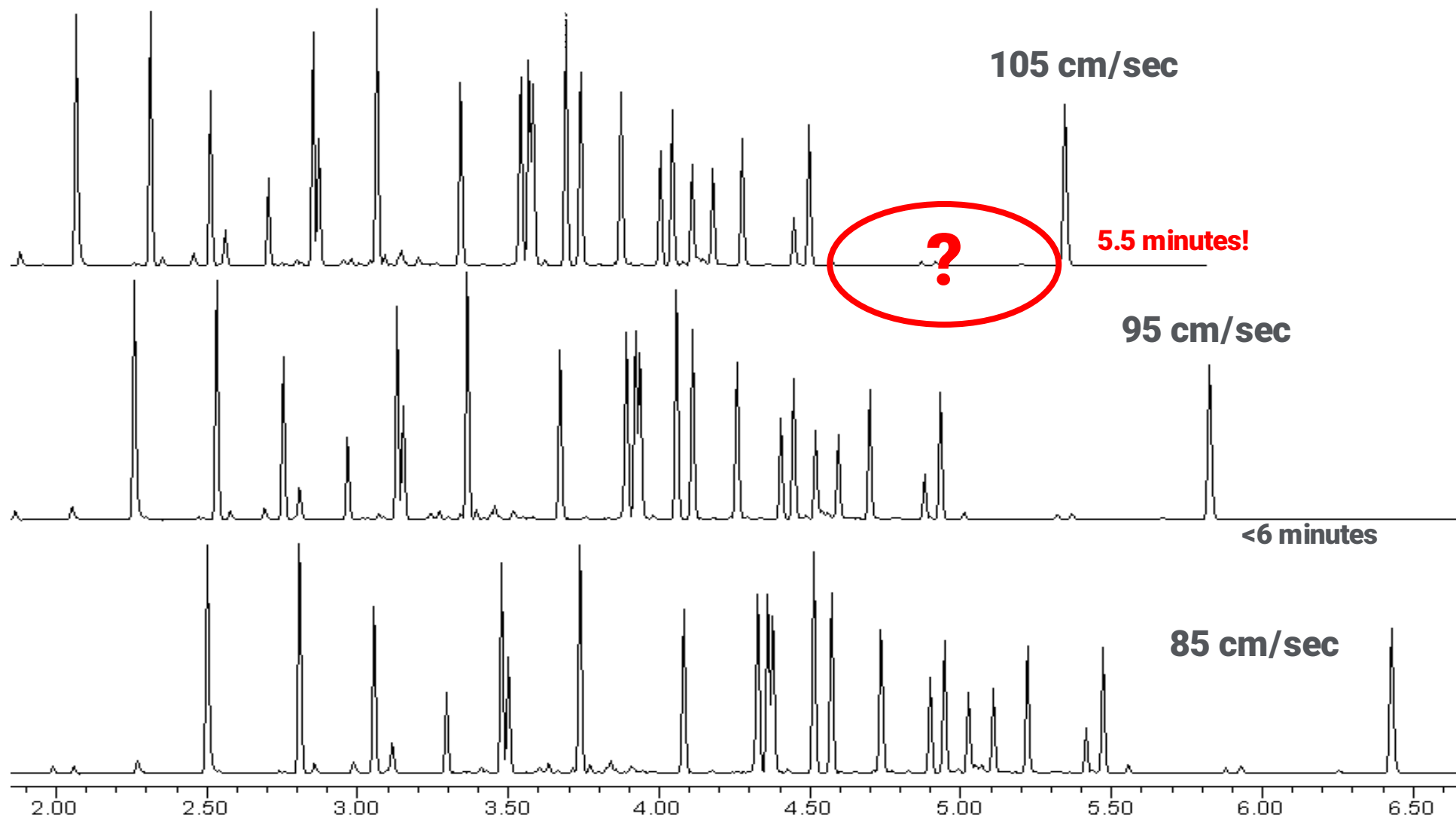
Ramp	Ramp Rate (°C/min)	Final Temp. (°C)	Final Time (min)
Initial		120	1.17
Ramp 1	25	160	0
Ramp 2	10	260	0
Ramp 3	15	300	4

Ramp	Ramp Rate (°C/min)	Final Temp. (°C)	Final Time (min)
Initial		120	0.454
Ramp 1	64.440	160	0.000
Ramp 2	25.776	260	0.000
Ramp 3	38.664	300	1.552

Ramp	Ramp Rate (°C/min)	Final Temp. (°C)	Final Time (min)
Initial		120	0.406
Ramp 1	72.021	160	0.000
Ramp 2	28.809	260	0.000
Ramp 3	43.213	300	1.388

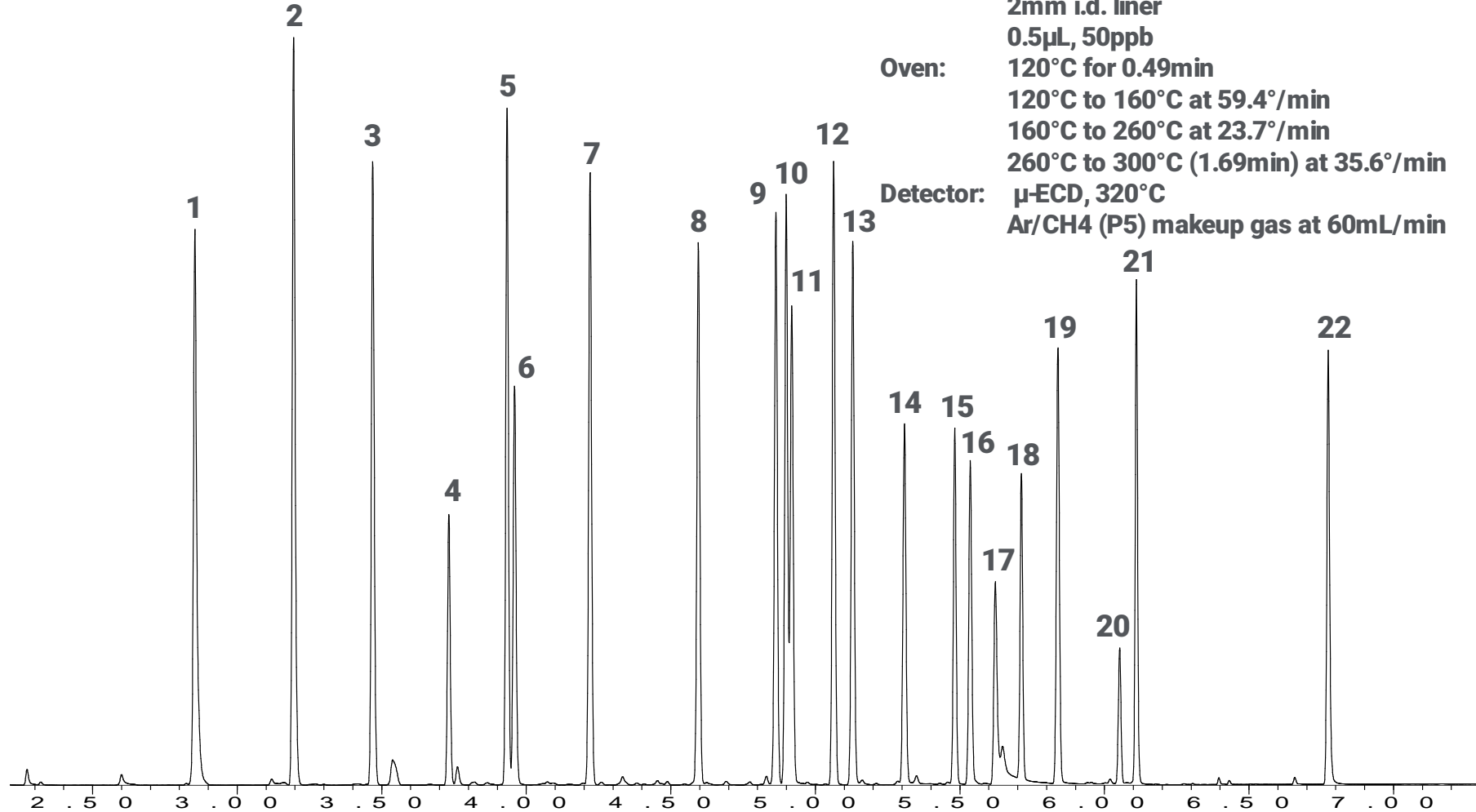
Sample Information: None

New Column Dimensions, H₂ Gas, Higher Velocities

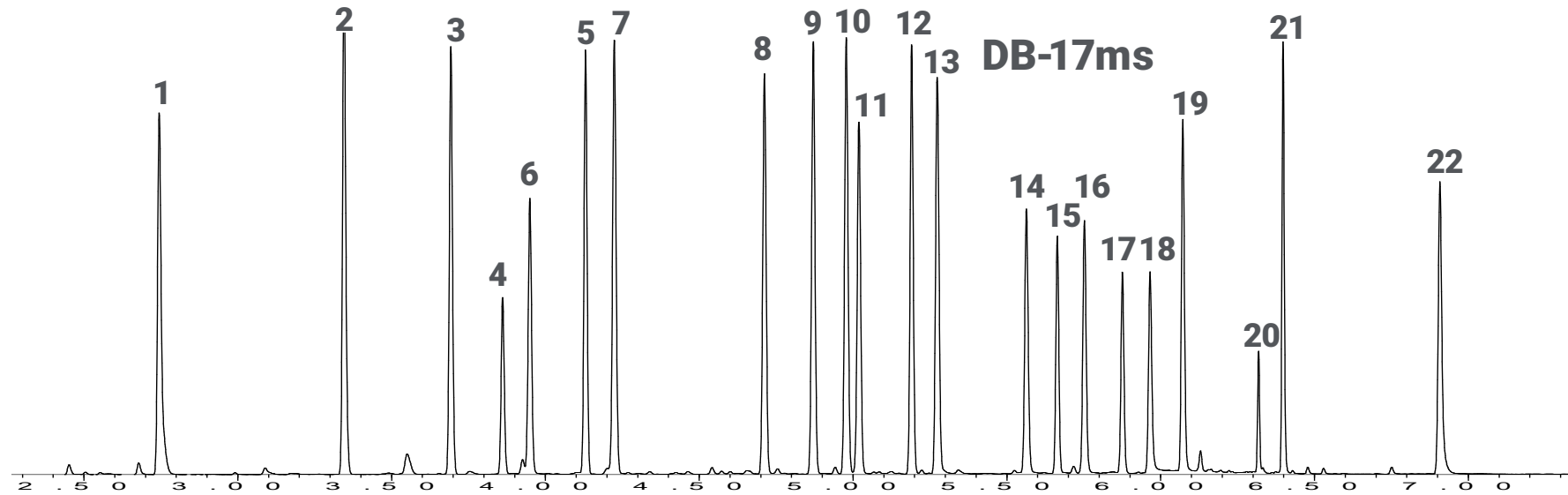
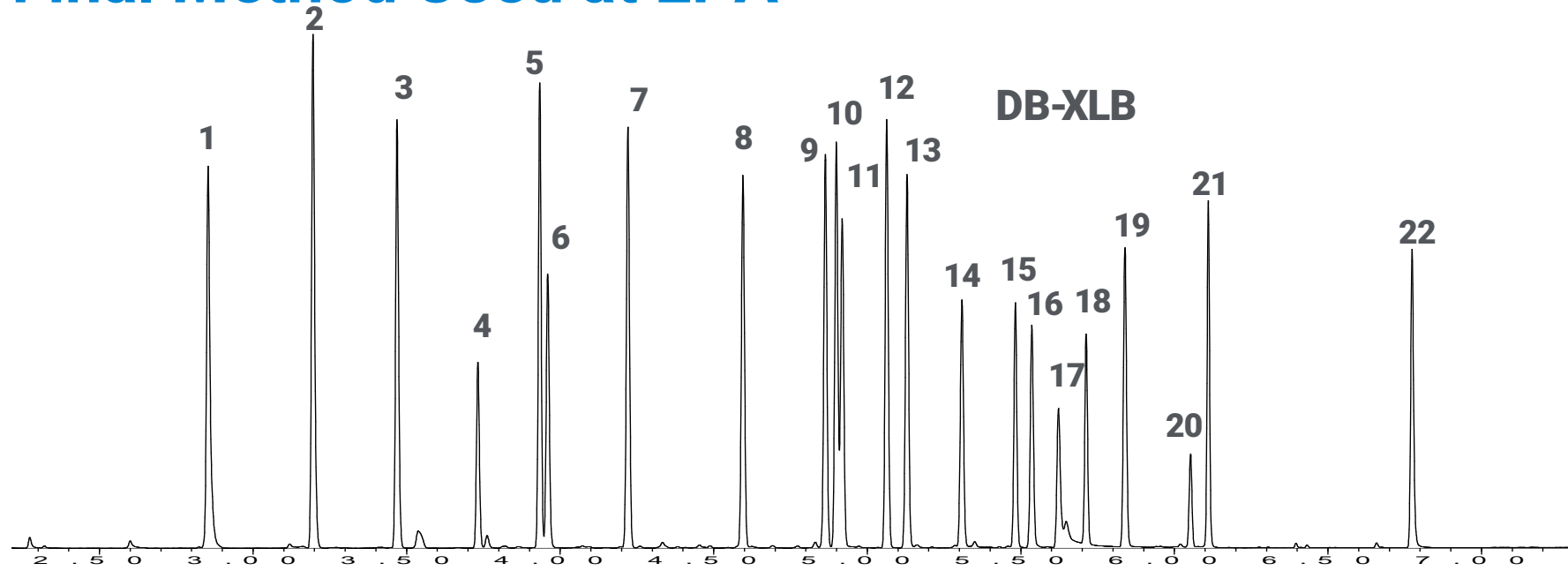


Final Method Used at EPA

Column: DB-XLB
20m x 0.18mm i.d., 0.18 μ m
Carrier: H2, constant flow, 77.3cm/s at 120°C
Injector: Pulsed Splittless, 220 °C
Pulse pressure & time: 35psi for 0.5min
Flow ramp at 6.25min of 99mL/min² to 3mL/min
2mm i.d. liner
0.5 μ L, 50ppb
Oven: 120°C for 0.49min
120°C to 160°C at 59.4°/min
160°C to 260°C at 23.7°/min
260°C to 300°C (1.69min) at 35.6°/min
Detector: μ -ECD, 320°C
Ar/CH4 (P5) makeup gas at 60mL/min



Final Method Used at EPA



Food/Fragrance – Method translation

GC Method Translation

Criterion: Translate Only Best Efficiency Fast Analysis None **Speed gain: 1.55885**

	Original Method	Translated Method																								
Column																										
Length, m	30	<input type="checkbox"/> 20																								
Internal Diameter, μm	250.0	<input type="checkbox"/> 180																								
Film																										
Thickness, μm	0.250	<input type="radio"/> Unlock																								
Phase Ratio	250.0	<input type="radio"/> 0.180																								
		<input checked="" type="radio"/> 250.0																								
Carrier Gas	Helium	<input type="checkbox"/> Helium																								
Enter one Setpoint																										
Head Pressure, psi	0.563	5.698																								
Flow Rate, mLn/min	0.4833	0.3480																								
Outlet Velocity, cm/sec	Very large	Very large																								
Average Velocity, cm/sec	25.00	25.98																								
Hold-up Time, min	2.00000	1.28300																								
Outlet Pressure (absolute), psi	0	<input checked="" type="checkbox"/> 0																								
Ambient Pressure (absolute), psi	14.696	<input type="checkbox"/> 14.696																								
Oven Temperature 1-ramp Program																										
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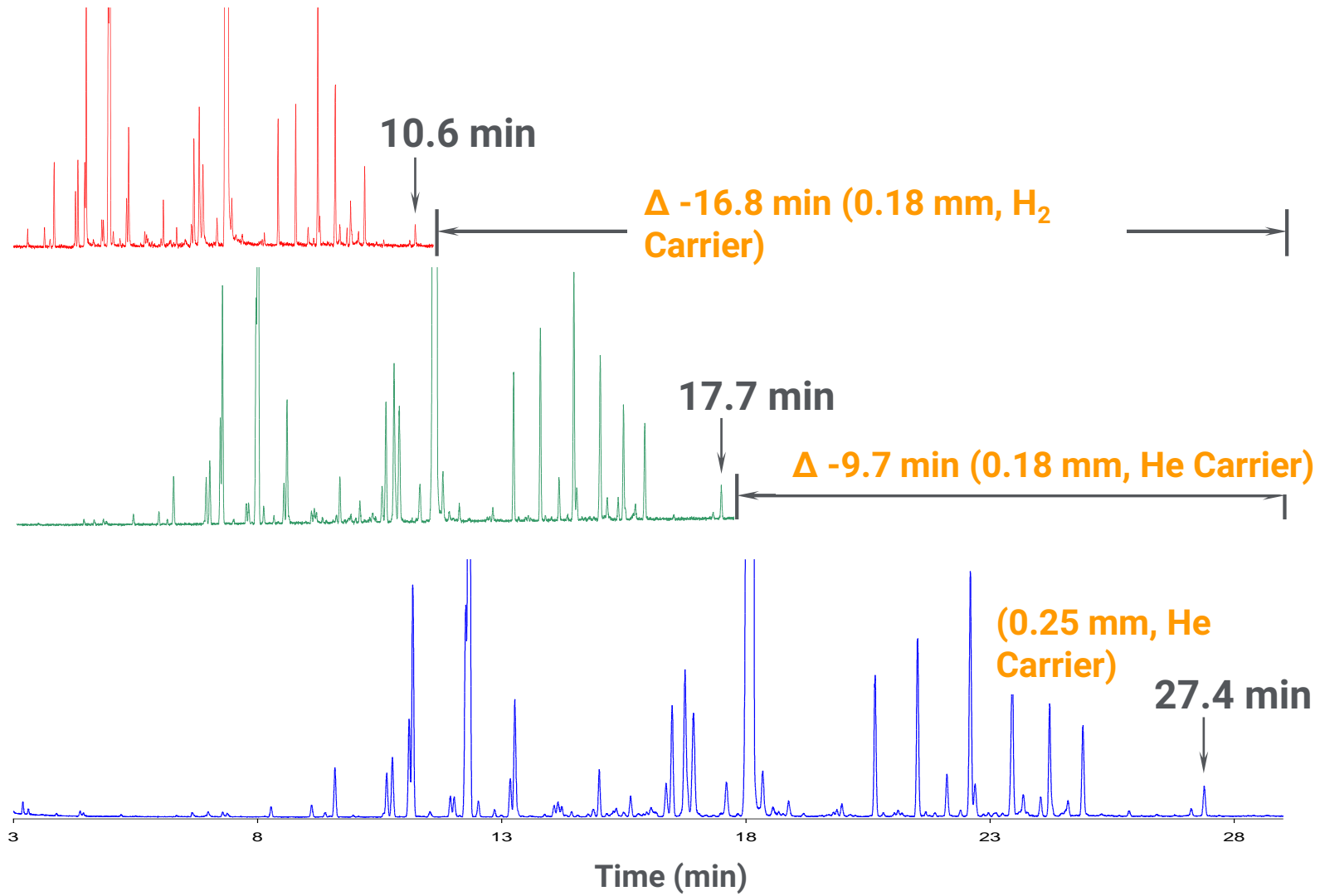
Food/Fragrance – Method translation

GC Method Translation - □ ×

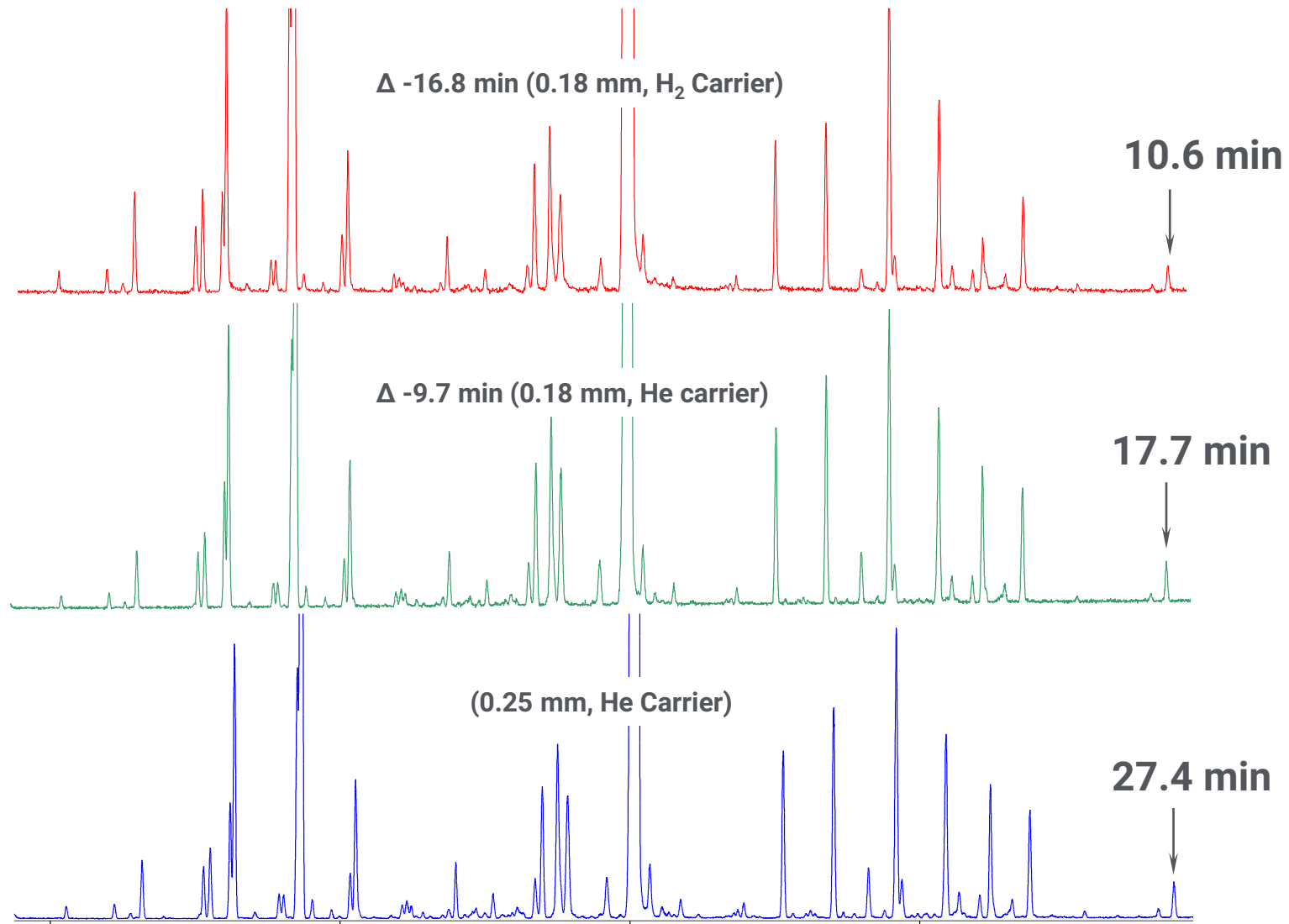
Criterion: Translate Only Best Efficiency Fast Analysis None Speed gain: 2.59618

	Original Method	Translated Method																								
Column																										
Length, m	30	<input type="checkbox"/> 20																								
Internal Diameter, μm	250.0	<input type="checkbox"/> 180																								
Film		<input type="radio"/> Unlock																								
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Hold-up Time, min	2.00000	0.770362																								
Outlet Pressure (absolute), psi	0	<input checked="" type="checkbox"/> 0																								
Ambient Pressure (absolute), psi	14.696	<input type="checkbox"/> 14.696																								
Oven Temperature 1-ramp Program																										
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Ramp Rate</th> <th>Final Temp.</th> <th>Final Time</th> </tr> <tr> <th>$^{\circ}\text{C}/\text{min}$</th> <th>$^{\circ}\text{C}$</th> <th>min</th> </tr> </thead> <tbody> <tr> <td style="background-color: black; color: white;">Initial</td> <td>40</td> <td>1</td> </tr> <tr> <td>Ramp 1</td> <td>5</td> <td>290 0</td> </tr> </tbody> </table>	Ramp Rate	Final Temp.	Final Time	$^{\circ}\text{C}/\text{min}$	$^{\circ}\text{C}$	min	Initial	40	1	Ramp 1	5	290 0	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Ramp Rate</th> <th>Final Temp.</th> <th>Final Time</th> </tr> <tr> <th>$^{\circ}\text{C}/\text{min}$</th> <th>$^{\circ}\text{C}$</th> <th>min</th> </tr> </thead> <tbody> <tr> <td style="background-color: black; color: white;">Initial</td> <td>40</td> <td>0.385</td> </tr> <tr> <td>Ramp 1</td> <td>12.981</td> <td>290 0.000</td> </tr> </tbody> </table>	Ramp Rate	Final Temp.	Final Time	$^{\circ}\text{C}/\text{min}$	$^{\circ}\text{C}$	min	Initial	40	0.385	Ramp 1	12.981	290 0.000
Ramp Rate	Final Temp.	Final Time																								
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$^{\circ}\text{C}/\text{min}$	$^{\circ}\text{C}$	min																								
Initial	40	0.385																								
Ramp 1	12.981	290 0.000																								
Sample Information None																										

Spearmint Oil



Spearmint Oil – Resolution Check



Resolution Maintained

Compound Resolution			
Compounds	0.25 mm Helium	0.18 mm Helium	0.18 mm Hydrogen
Sabinene	1.52	1.59	1.56
β -Pinene			
α -Terpinene	1.61	1.73	1.86
p-Cymene			
Speed Gain	N/A	35%	61%

CONCLUSIONS

Stationary Phases – Chosen for optimized selectivity

Diameter – Smaller allows shorter length but has less capacity

Make Small Changes – Again think capacity

Carrier Gas – Hydrogen, high velocity, but can still go fast with He

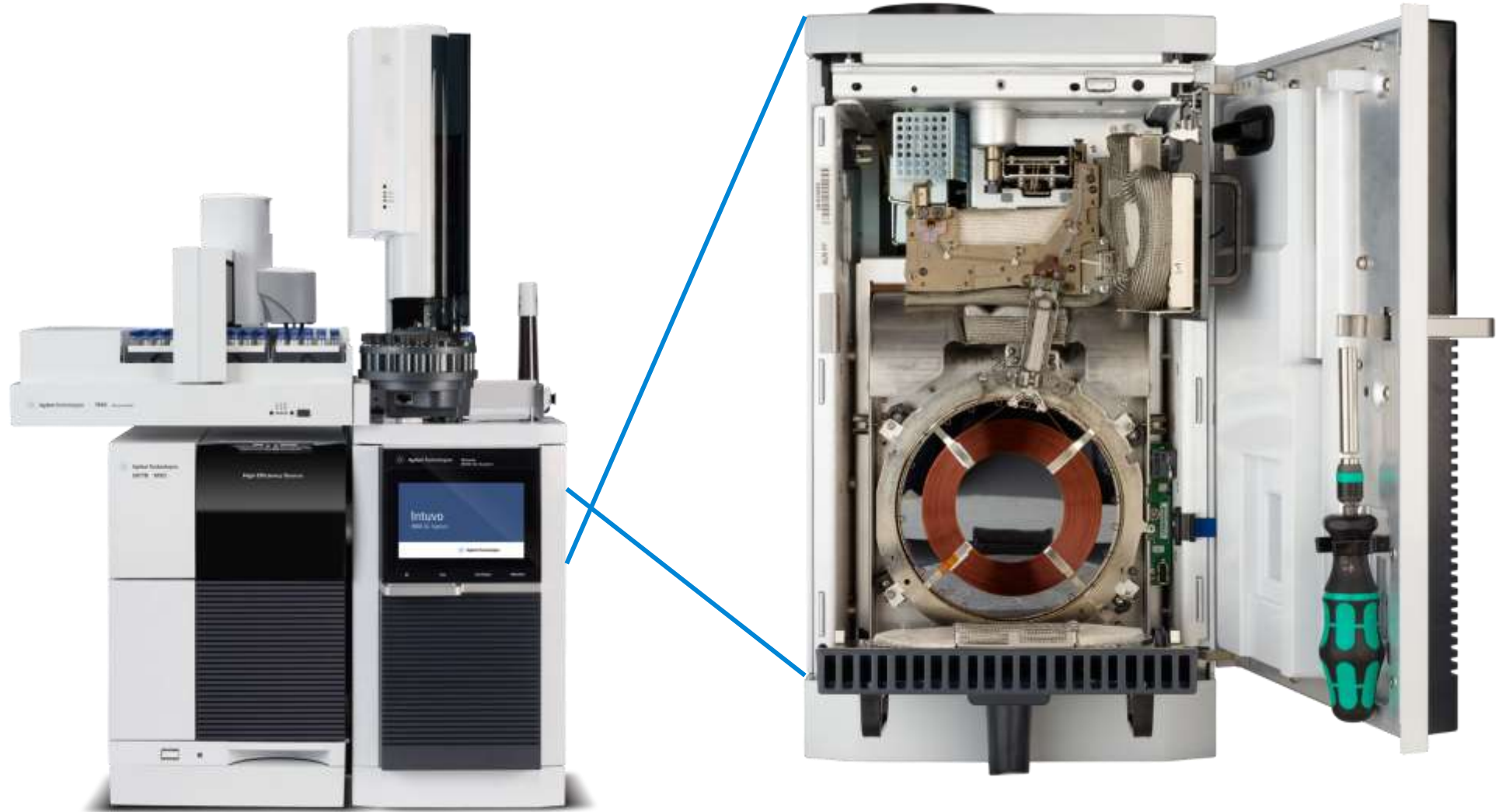
Temperature Program – Scale properly to preserve elution pattern

Method Translation Software – FREE, reliable

Flow Ramp – Increase at end of run for late eluters (if necessary)

System Upgrades – LTM, Capillary Flow Devices (back flush)

The New Agilent Intuvo 9000 GC System

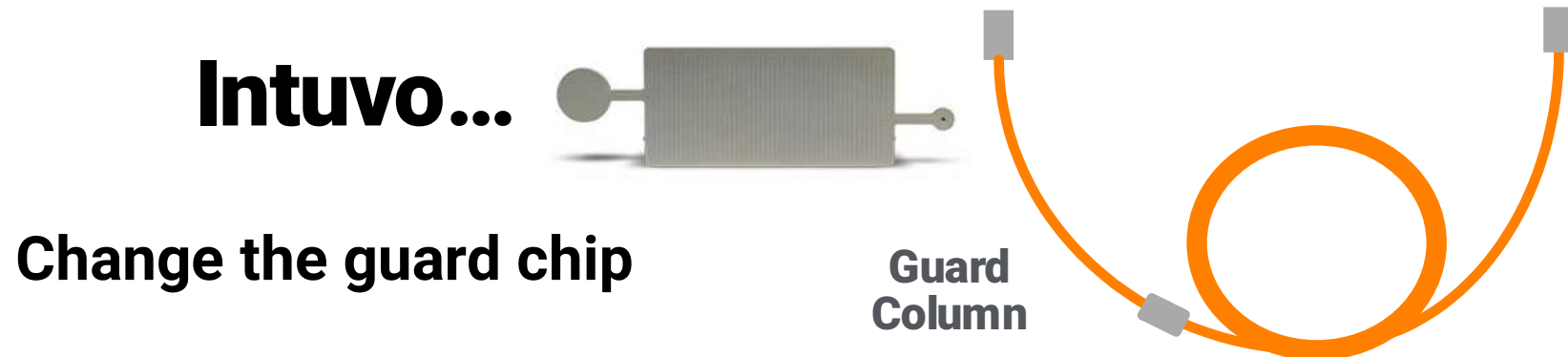


Common frustrations with GC

- **Measuring column length correctly**
- **Cutting your column correctly**
- **How tight is too tight?**
- **Clipping columns to deal with active sites, then updating retention times**

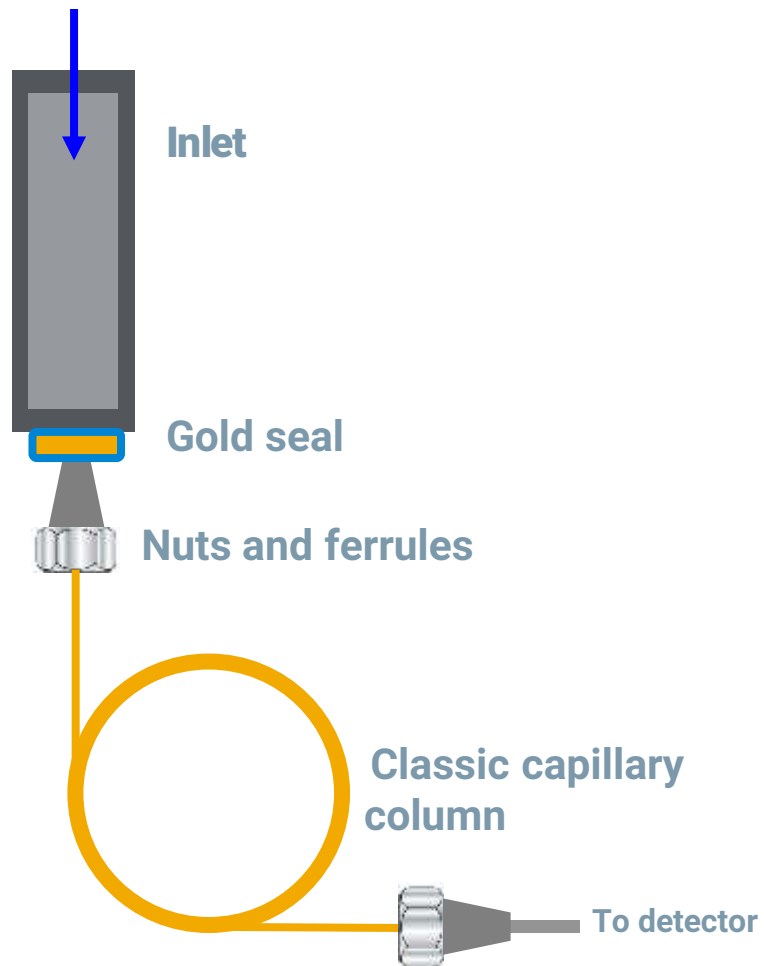
Common Care and Maintenance Scheme for GC Columns

1. Cut off 6"-1ft of the inlet end of the column.
2. Bake out the column for no more than 2 hours.
3. Cut off more column. (repeat as necessary)

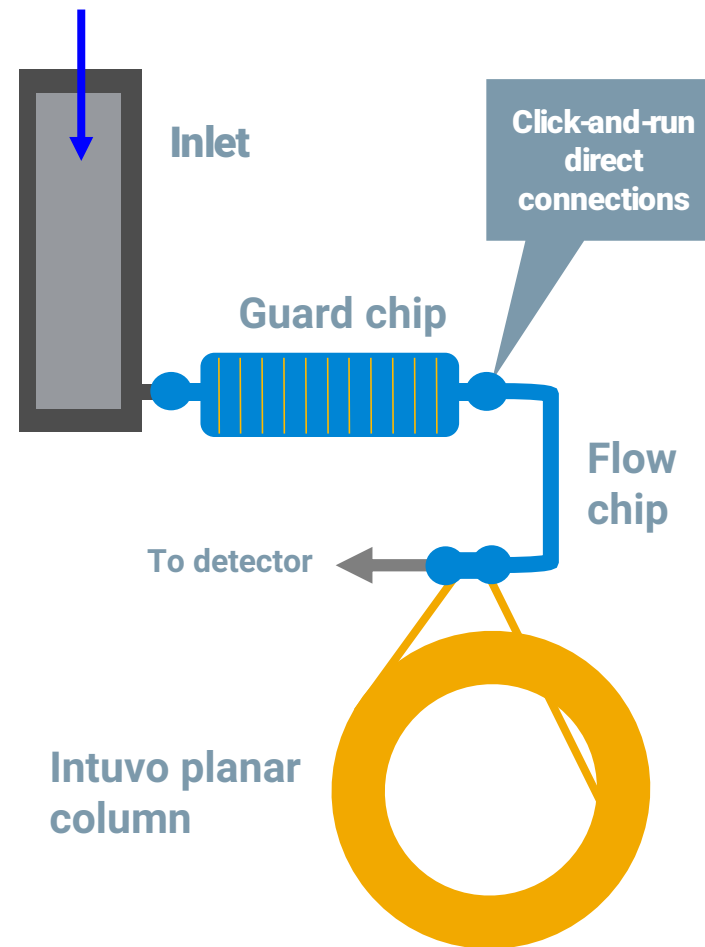


Innovating the GC Flow Path

Conventional flow path

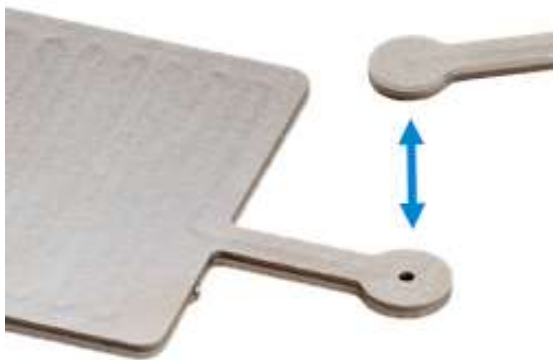


Intuvo flow path



Easier and faster maintenance with Intuvo

- No more ferrules
- Direct face seal connections
- Audible and tactile click lets you know connection is made
- Less unplanned downtime
- Fewer batch reruns and precious samples lost



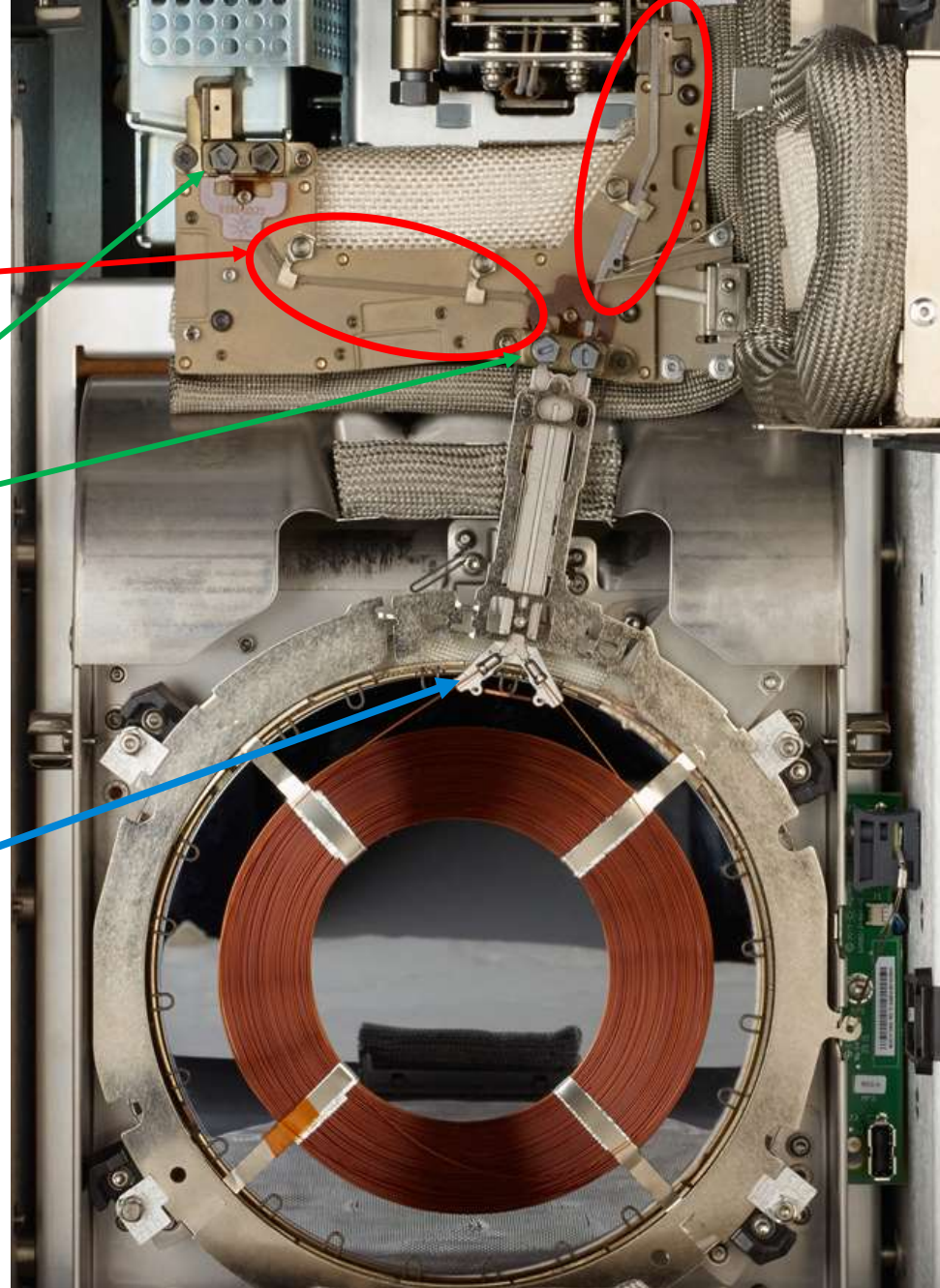
No More

- measuring

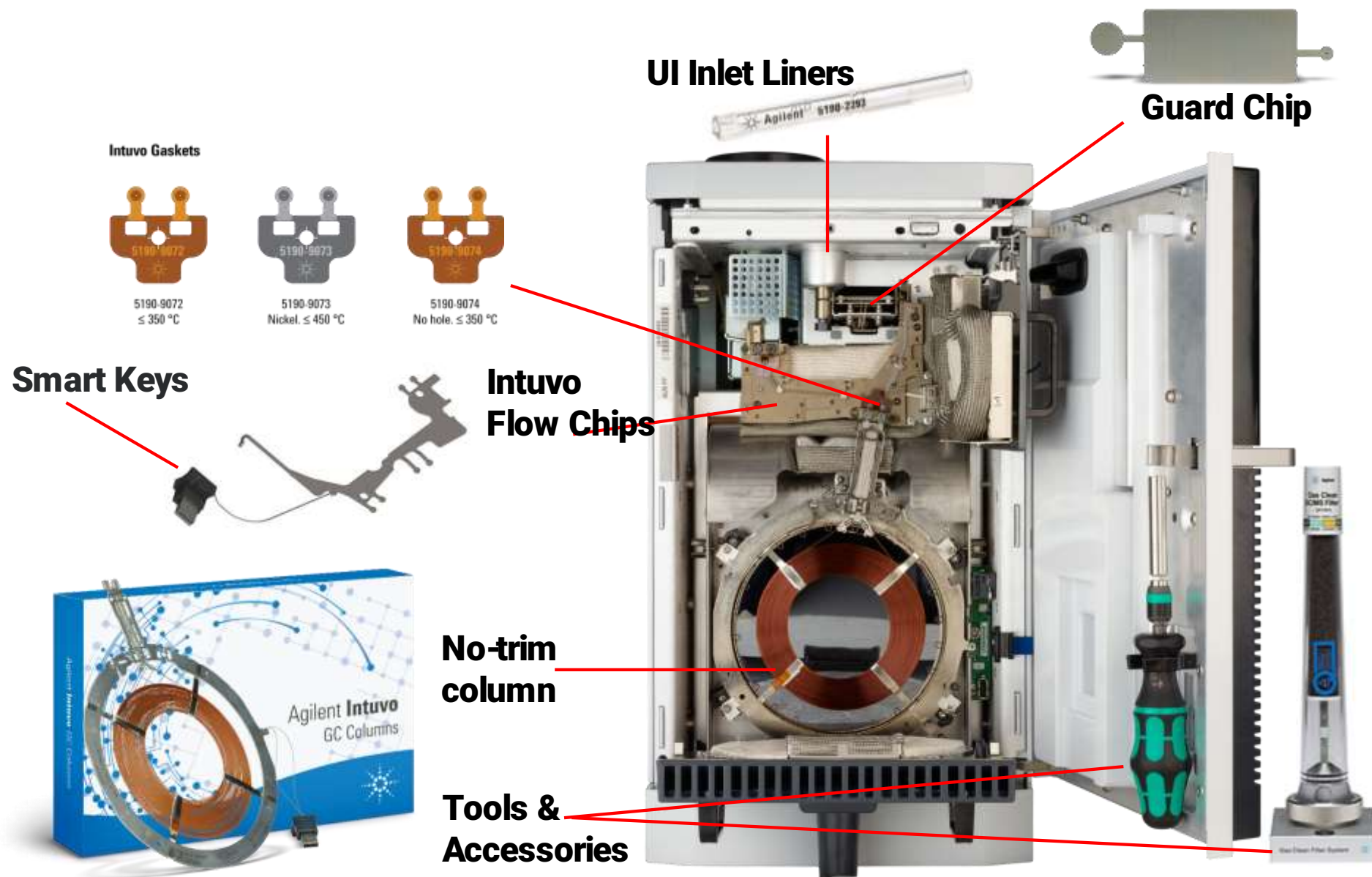
- over-tightening



- trimming



A New Portfolio of GC Consumables



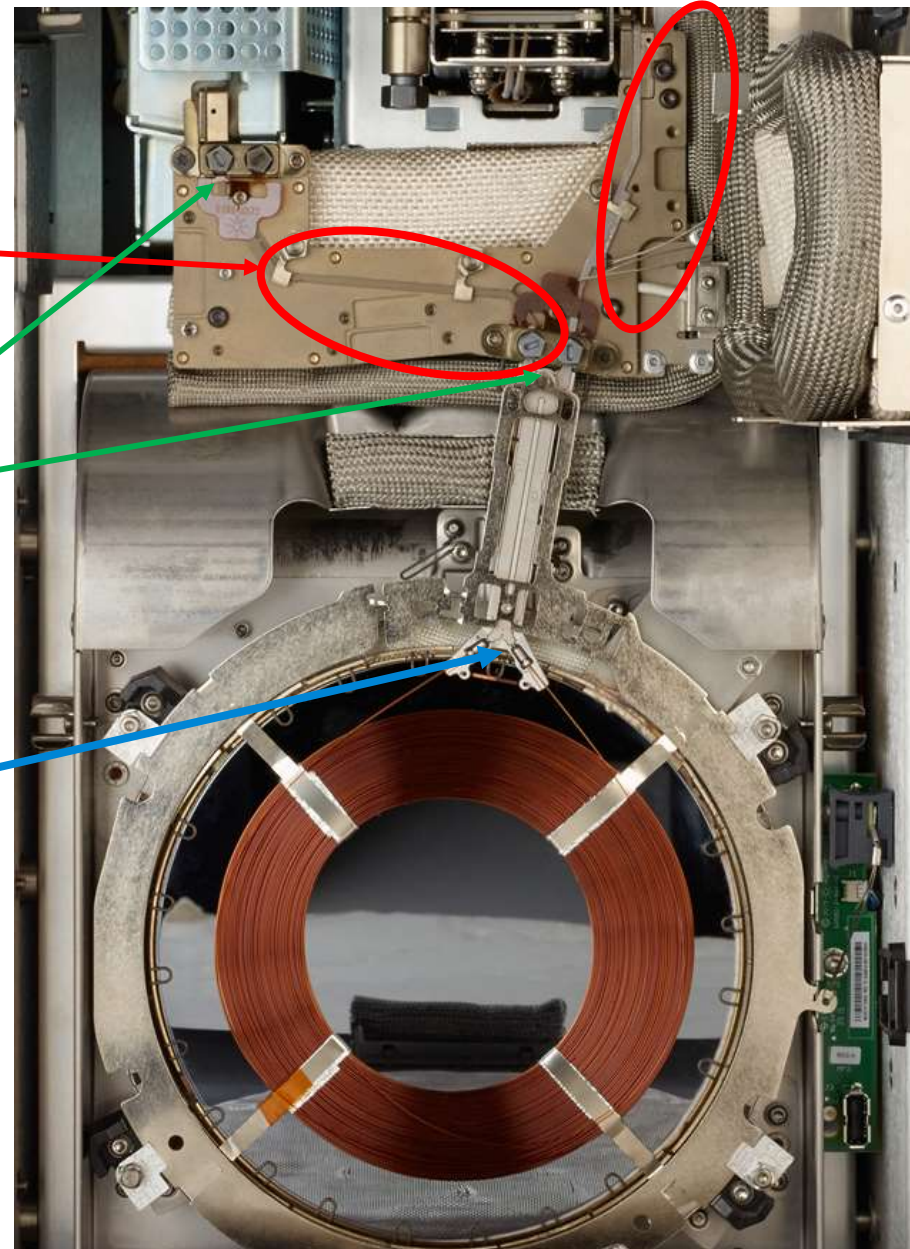
No More:

- Measuring

- Over-tightening



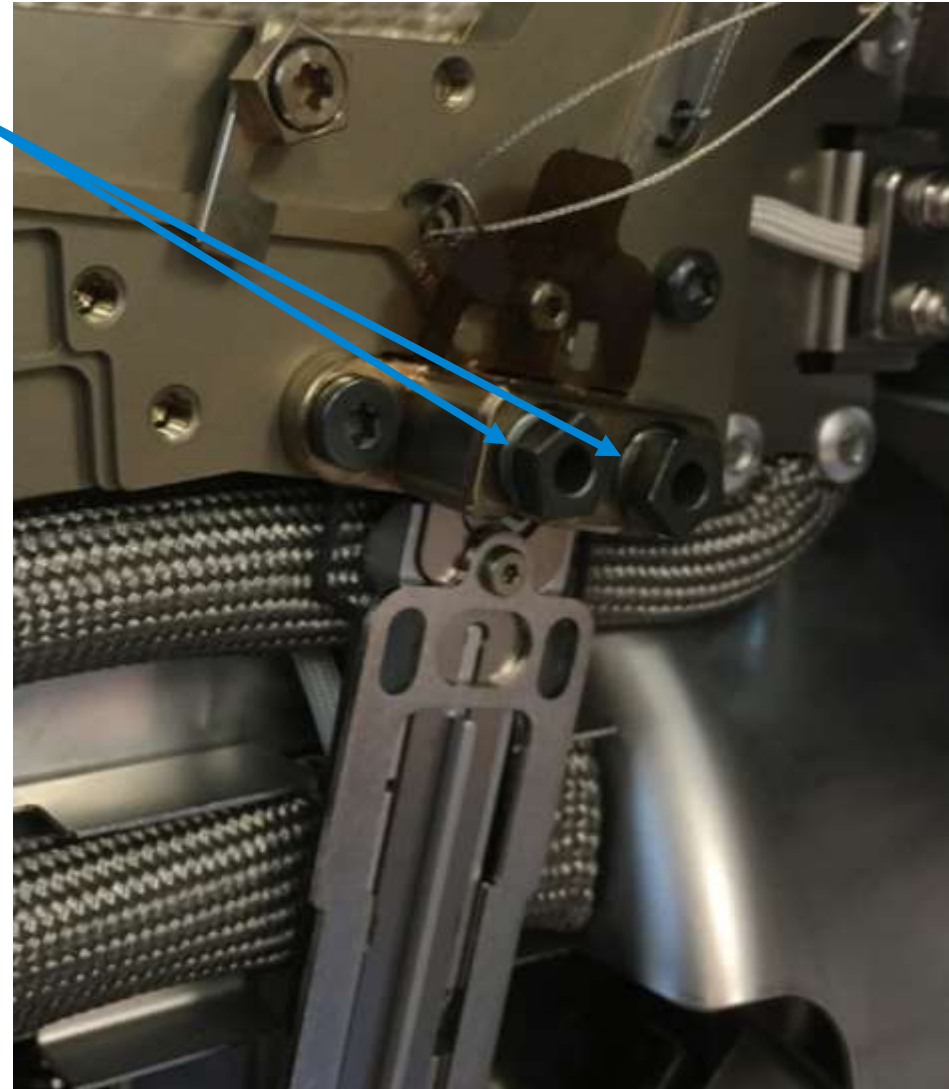
- Trimming



Tips to Assure a Good Column Installation

1. **Finger tighten until only 1 thread on each of the two nuts is showing.**

If more than 1 thread is showing, wiggle or re-position the column into place to further finger tighten the nuts to 1 thread.



Tips to Assure a Good Column Installation

2. Check that the small integrated column nuts on the column are in form fitted place on the heater in the instrument.
3. Click and Run!!



Smart Key Technology

- Smart chip tells your Intuvo what you have
- Sets temperature limits for you
- Keep track of performance with read/writeable Smart Key



Where Does it Get Dirty?

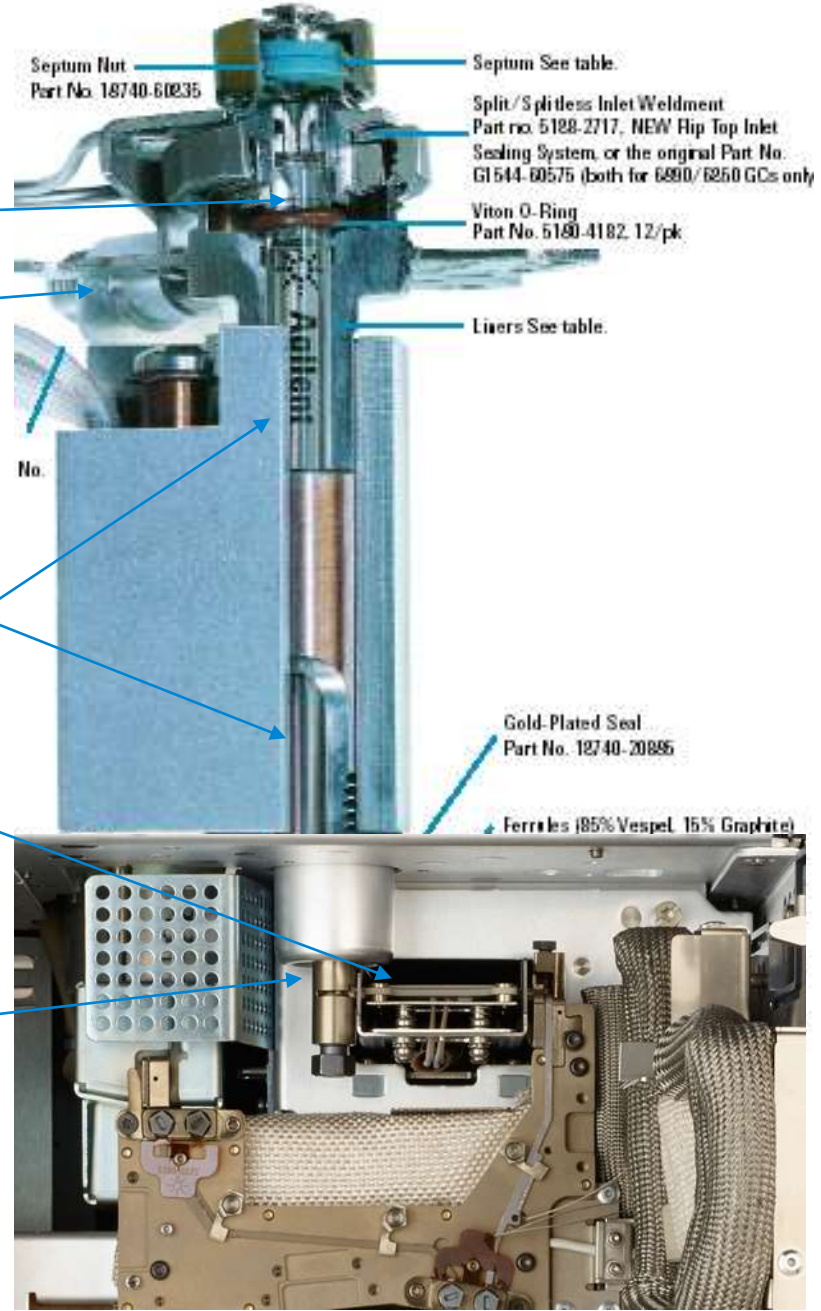
Here

Here

Here

Here

Here



Not the Column!

New Autonomous Leak Checking

